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Proceedings of the Tenth Annual Meeting of the Cotton States Branch American Association of Economic Entomologists[1]

The tenth annual meeting of the Cotton States Branch was held at Atlanta, Georgia, on January 31 and February 1, 1935, in conjunction with the annual convention of the Association of Southern Agricultural Workers. This was perhaps the most interesting and instructive meeting ever held by the Branch, and many considered it better than any previous meeting. Of special interest was the timely symposium on The Screw Worm Situation in the Southeast attended by the Animal Husbandry and Dairy Science Sections of the Association of Southern Agricultural Workers as guests of the Branch. The first day was designated as Cotton Day by the Association at which time all papers on cotton, including those dealing with insects attacking that plant, were read. Considerably more than the usual number of titles were submitted for the annual meeting of the Branch, and as a result only the papers of those present could be given in full during the two day session. The Chairman's address was discussed by Dr. S. Marcovitch who expressed a debt of gratitude for calling attention to the entomological possibilities in the Southern region. Dr. F. C. Bishopp gave an address on the Screw Worm at a general session of the Association of Southern Agricultural Workers and also participated in the symposium on that subject at the meeting of the Branch. Informal discussions followed the presentation of most of the papers, which brought out additional points of interest.

The attendance was larger than that of any meeting since the depression began, and the Branch was honored by the presence of Mr. Lee A. Strong, President of the American Association of Economic Entomologists and Chief of the U. S. Bureau of Entomology and Plant Quarantine. In response to an invitation for remarks, Mr. Strong gave a brief report on the Pittsburgh meeting of the Parent Association and

[1]Limited funds have made it necessary, with the consent of the Secretary of the Southern Branch, to omit from the Proceedings papers presented by non-members and those not read by the authors themselves.

mentioned certain phases of the work of the Bureau. Mr. Avery S. Hoyt, Assistant Chief, and heads of four divisions of the U. S. Bureau of Entomology and Plant Quarantine attended the meeting. The President of the American Association of Economic Entomologists appointed Mr. Manning S. Yeomans, State Entomologist of Georgia, as the official representative of the parent Association at the annual meeting of the Branch in Atlanta. He attended in that capacity and will report on same at the next annual meeting of the parent Association in St. Louis.

The members of the Cotton States Branch and all delegates to the annual convention of the Association of Southern Agricultural Workers were guests at two elaborate banquets in Atlanta, which included programs of entertainment.

PART I. BUSINESS PROCEEDINGS

The meeting was called to order by Chairman S. W. Bilsing at 9:00 A. M. on January 31 in the Henry Grady Hotel at Atlanta, Georgia. The following were present:

C. H. Alden, Cornelia, Ga.
W. B. Alford, Gulfport, Miss.
F. S. Arant, Auburn, Ala.
P. J. D. Arnold, Gainesville, Fla.
J. T. Arrendale, Tiger, Ga.
S. W. Bilsing, College Station, Texas.
F. C. Bishopp, Washington, D. C.
Theo. L. Bissell, Experiment, Ga.
K. K. Boyd, Chicago, Ill.
G. H. Bradley, Orlando, Fla.
W. H. Clarke, Thomaston, Ga.
L. M. Clarkson, Atlanta, Ga.
R. P. Colmer, State College, Miss.
John T. Creighton, Gainesville, Fla.
W. E. Dove, Savannah, Ga.
David Dunavan, Clemson College, S. C.
E. W. Dunnam, Stoneville, Miss.
Alfred Fenton, Houston, Texas.
F. A. Fenton, Stillwater, Okla.
J. E. Foster, Raleigh, N. C.
B. M. Gaddis, Washington, D. C.
R. C. Gaines, Tallulah, La.
F. E. Guyton, Auburn, Ala.
R. W. Harned, Washington, D. C.
J. A. Harris, Raleigh, N. C.
H. W. Harvey, Athens, Ga.
A. M. Henry, Atlanta, Ga.
A. S. Hoyt, Washington, D. C.
J. W. Ingram, Houma, La.
M. P. Jones, Washington, D. C.
W. V. King, Orlando, Fla.
Clay Lyle, State College, Miss.
S. Marcovitch, Knoxville, Tenn.
J. J. McManus, Atlanta, Ga.
R. H. Means, State College, Miss.
Ralph L. Miller, New Orleans, La.
G. F. Moznette, Albany, Ga.
W. A. Murrell, Savannah, Ga.
W. C. Nettles, Clemson College, S. C.
Tom O'Neill, Atlanta, Ga.
C. F. Rainwater, Florence, S. C.
W. V. Reed, Laurel, Miss.
R. C. Roark, Washington, D. C.
J. M. Robinson, Auburn, Ala.
Oliver I. Snapp, Fort Valley, Ga.
Herbert Spencer, Albany, Ga.
W. W. Stanley, Knoxville, Tenn.
Lee A. Strong, Washington, D. C.
H. S. Swingle, Auburn, Ala.
J. R. Thomson, Fort Valley, Ga.
W. H. Tisdale, Cleveland, Ohio.
J. N. Todd, Clemson College, S. C.
Wm. F. Turner, Fort Valley, Ga.
J. G. Watts, Clemson College, S. C.
R. D. Whitmarsh, Cleveland, Ohio.
M. S. Yeomans, Atlanta, Ga.
W. P. Yetter, Jr., Cornelia, Ga.
H. C. Young, State College, Miss.

The report of the Secretary-Treasurer was then read and approved subject to the audit of the auditing committee.

Report of the Treasurer

Balance on hand February 1, 1934		$197.06
Refund from parent Association for postage, printing and telegrams during the year ending Jan. 31, 1934		21.00
Contribution		1.00
1931 annual dues from 1 member		1.00
1932 annual dues from 2 members		2.00
1933 annual dues from 6 members		6.00
1934 annual dues from 11 members		11.00
1935 annual dues from 4 members		4.00
Interest on deposit in Savings Department of First National Bank, Atlanta, Ga		2.76
Dividend (2%) on claim against closed Citizens Bank of Port Valley, Ga		.48
Paid out:		
Expense for annual meeting in Memphis (by action of Executive Committee)	$32.46	
Stamped envelopes and stamps	13.08	
Printing announcements and programs	7.00	
U. S. tax on 6 checks	.12	
	$52.66	$246.30
Balance on hand February 1, 1935	$193.64	

Report of the Secretary

The number of members in the Cotton States Branch on December 31, 1934 was 199. There was a net decrease of 20 members during the year, after removing the names of those who moved out of the Branch territory or were dropped by the parent Association for non-payment of dues. The net decrease during the last two years has been 35, due largely to economic conditions. Nevertheless, the membership is still greater than that of 1926 when there were but 158 names on the roll.

The number of members by states on December 31, 1934 was as follows: Texas 45; Mississippi 32; Louisiana 29; Florida 24; Georgia 15; North Carolina 13; South Carolina 11; Tennessee 10; Alabama 9; Arkansas 7; and Oklahoma 4. The following states showed net increases during the year: Louisiana 5; Alabama 1; and South Carolina 1. Net decreases during the year were as follows: Georgia 5; Tennessee 5; Texas 5; North Carolina 4; Florida 3; Mississippi 2; Oklahoma 2; and Arkansas 1. There are several hundred entomological workers in the 11 Cotton States who are not members of the American Association of Economic Entomologists, and members of the Branch are requested to urge these men to file application for membership in the parent Association.

The Secretary sent to each member of the Branch an invitation to participate in the regular annual meeting in Atlanta, Ga., on January 31 and February 1, 1935. The program for that meeting was mailed to each member on January 19. The proceedings of the Memphis meeting of the Cotton States Branch were published in the August, 1934 (Vol. 27, No. 4) issue of the Journal of Economic Entomology, and a report on that meeting was made at the annual meeting of the American Association of Economic Entomologists in Pittsburgh, Pa. on December 27, 1934.

Annual dues in the Cotton States Branch are $1.00. Thirteen of the 199 members have paid dues for 1934, and only four members have paid their 1935 dues which are now payable.

The Publications Committee announced that abstracts will not be required for the papers presented for publication in the proceedings of the Branch.

Chairman Bilsing appointed the following committees: Nominations—W. V. King, F. A. Fenton and J. M. Robinson. Auditing—G. F. Moznette, G. H. Bradley and E. W. Dunnam. Resolutions—S. Marcovitch, Clay Lyle and F. E. Guyton. Publications (standing) Oliver Snapp, Herbert Spencer and G. M. Bentley.

Final Business

Chairman Bilsing called for the report of committees.

The Auditing Committee reported that the books and accounts of the Branch had been carefully audited, and found to be correct. This report was then adopted by motion and vote and a certificate given to the Secretary-Treasurer.

The following resolutions were duly adopted after reading of the report of the Committee on Resolutions and the Secretary was instructed to send them to the parties concerned:

Be It Resolved by the Cotton States Branch of the American Association of Economic Entomologists in annual session in Atlanta:

(1) That in view of the gradually increasing number of papers presented at our meetings, each presentation of a paper in the future shall be limited to 10 minutes.

(2) That, abiding by the rule of the parent Association, future papers shall be limited to 6 pages in the Journal of Economic Entomology, any excess thereof to be paid for by the individual in accordance with the rules of the Journal.

(3) That members present shall be given priority in the presentation of the program. The papers of absent members shall be relegated to the end of the program and read by title, abstract, or in full, at the pleasure of the members present.

(4) That the Secretary of this Branch be instructed to convey to the management of the Henry Grady Hotel our appreciation for the excellent facilities provided for our meeting.

The Nominations Committee presented the following names for officers during the ensuing year: Chairman—Clay Lyle, State College, Miss.; Vice-Chairman—R. C. Gaines, Tallulah, La. These officers were duly elected by motion and vote, and the new chairman was escorted to the chair where he was duly installed. Secretary-Treasurer Oliver Snapp was elected in 1934 for a three-year term.

Past Chairman Bilsing then announced that The Texas Entomological Society had under consideration the filing of an application with the parent Association for a new Branch to be known as the Southwestern Branch to include besides Texas—Oklahoma, Arkansas, Louisiana, New Mexico and perhaps Arizona. Considerable discussion followed and finally by vote and motion the Chairman of the Cotton States Branch was authorized to communicate with the Executive Committee of The Texas Entomological Society and the Executive Committee of the American Association of Economic Entomologists in regard to an adjustment of any reason which may be presented for dividing the territory now under the jurisdiction of the Cotton States Branch.

Upon motion of the Secretary, the Branch voted to hold the 1936 meeting at the place and time designated by the executive committee of the Association of Southern Agricultural Workers for the next annual convention of that Association.

PART II. PAPERS

The session for addresses and presentation of papers convened immediately following the business session with Chairman Bilsing presiding.

CREATING AN ENTOMOLOGICAL ATMOSPHERE IN THE SOUTH

By S. W. BILSING, *Texas A. & M. College, College Station, Texas*

In reviewing the addresses of the Chairmen of this Branch of the American Association of Economic Entomologists, one is impressed by the variety of subjects which have been selected for discussion. Some have dwelt at length on forecasting the future; others have discussed in detail the special problems with which they have come in contact; still others have indulged in a historical review of the accomplishments of their Science; again others have engaged in a critical discussion of existing conditions as they have viewed them. The subject I have chosen is one which has been brought to my attention for a period of years thru contacts with students and the general public.

Entomology is still a young Science. The writer cannot claim to be a pioneer in the development of this science in the South since the initial studies on the boll weevil were begun in 1901 at Victoria, Texas, by Dr. W. D. Hunter and his associates several years before the writer's advent into entomological work. Yet it is not possible to forego the temptation to review what has and has not been accomplished since that time as well as to speculate on what we should attempt to accomplish in the future. It is well known that no law can long endure unless it is supported by public opinion. It is perhaps equally true that the proper advancement cannot be made in such a science as that of entomology unless a proper atmosphere is created by the men who are engaged in promoting it. While it may be possible to successfully consummate a campaign for the eradication of some important insect in spite of continued opposition from a large number of people, it seems evident that more lasting good could be accomplished if the right attitude of mind had been inculcated in the public before the emergency ever arose. Such a condition cannot result from the promotion of adequate propaganda at the time of the emergency but must be engendered thru a long period as a result of the labors of sincere and industrious men who are devoted to the advancement of their profession. All of us believe that advances in entomology are necessary for the comfort and health of man. Granting that to be the case, let us try to evaluate means by which we might carry this gospel to the people who in the end are to be benefitted and who must support the program thru a long period of years if it is ever to accomplish what it should.

To impart enthusiasm to others, it is first necessary to be enthusiastic ones self. One of the best ways to acquire such an enthusiasm is to study

the accomplishments of the men not only in entomological fields, but in other fields of scientific endeavor. But since this is an entomological discussion, for lack of time, we shall confine our remarks to a review of the accomplishments of a few men who have devoted their lives to the promotion of entomological work in the South. Nowhere on the North American continent have insects exerted so much influence on the social and economic development of the inhabitants as they have in the South. Entomologists have done much to make the South a better place in which to live. It is to the credit of many of them that they have "stayed by their guns in times of peril" regardless of vigorous and continued opposition from the very people whom they were trying to benefit.

Prior to the coming of the boll weevil and the establishment of the agricultural experiment stations there was very little interest in entomological work in the South. The Civil War had left the South in a bankrupt condition and the young men who went North or East to receive an education interested themselves in other studies than that of obtaining a knowledge of insects. The advent of the boll weevil in 1892 was responsible for a beginning in bringing the attention of the public to a realization of the importance of the influence of insects in the agricultural and economic development of the South. This insect, as is well known, has to a considerable extent occupied the center of attention ever since that time. By 1901 it had spread over a large part of Texas and Dr. W. D. Hunter together with his associates, Hinds, Morrill, Hooker, Yothers, Bishop, A. C. Morgan, and W. D. Pierce, began an intensive study of the life history with a view of ascertaining practical methods of control. The damage due to this insect during these first years was tremendous. Thousands of acres of cotton did not produce enough bolls to justify picking the cotton. Cotton growers were slow to adopt the recommendations made by Dr. Hunter and his associates. In order to get the planters to make a test of his recommendations, it was necessary for Dr. Hunter to enter into contracts with planters promising to reimburse them if the cotton did not make a greater yield when grown under his recommendations than by following the methods which they were accustomed to follow. The inertia on the part of the planters led those interested in the economic well being of the South to urge upon Congress to appropriate a small sum of money to send some one to demonstrate the value of following out these recommendations. Accordingly in 1904 Dr. Seaman A. Knapp was sent to East Texas to demonstrate methods to the farmers whereby they could benefit from following the results of scientific research. This movement spread throughout the Cotton Belt and culminated in the enactment of the Smith Lever Bill which established our present efficient system of County Agricultural Agents. The enforced change in the production of cotton due to the advent of the boll weevil resulted in reorganizing our system of agriculture; indirectly in diversified farming; and in a well organized system of imparting scientific information to a large part of the agricultural population of the South. Research work on the boll weevil has resulted in other discoveries which

have been of great benefit not only to the people of the South, but to the whole country. In 1906 Dr. Wilmon Newell and his associates in the Louisiana State Crops Pest Commission succeeded in producing powdered arsenate of lead and soon afterward the manufacture of it was begun on a commercial scale. This led later on to the development of calcium arsenate by Coad and his associates at the Boll Weevil Laboratory at Tallulah, Louisiana. All of these researches have led to the development of efficient dusting machinery of a great variety of kinds and for a variety of purposes.

Another discovery which has been of inestimable importance to the well being of mankind was the discovery that certain arthropods were capable of transmitting diseases of both man and other animals. Smith, Kilbourne, and Curtice of the U.S.D.A. in 1893 proved that Texas Fever in cattle was transmitted by the cattle tick, *Margaropus annulatus*. This opened the way to a long series of discoveries of insect-borne diseases which has made many uninhabitable places inhabitable and saved thousands of lives in many parts of the world. About 1904 Dr. H. A. Morgan having completed his studies on the life history of the Texas fever tick conceived the possibility of eradicating the cattle tick and also proposed methods of doing it. This dream is about to be realized after a period of more than 30 years, and when it is accomplished, Texas Fever will have been banished from an area of 730,000 sq. miles. Altho entomologists can claim only a part in the prosecution of this work, yet the scientific data on which this eradication program was developed was in part determined by entomological workers.

The South in the future as it has in the past must act as a buffer zone to a great part of the rest of the United States in detecting the introduction of and preventing the establishment of injurious pests which may be introduced from other countries. The opening up of new routes of trade and the vast improvement in present day methods of transportation, place the South in a peculiarly strategic position. In the near future much more of our commerce will be with our neighbors to the South of us. Improved highways are being built into Mexico which in time will connect us with both the Central and South American republics. Air transportation will make possible the introduction of insects and insect-borne disease from these countries. All of these possibilities necessitate a closer cooperation between entomological workers in the South and the Latin American countries to the South of us. As a group we should seek to foster cooperation with scientists in those countries as well as try to understand the political and social problems of their constituents. This suggestion invites a discussion of the successful prosecution of the eradication of two important insects which, had they been allowed to become established, would have resulted in tremendous economic losses to the South.

In 1917, Ivan Shiller, an inspector of the Federal Horticultural Board, discovered a pink boll worm in a cotton field at Hearne, Texas. This was followed by the finding of pink boll worms in a great number of locations between Houston and Beaumont, Texas, and later in Calcasieu and Cameron Parishes in Louisiana. It is not necessary to recount all

the locations in which pink boll worms were found, but it suffices to say that altho the infestations were as a rule confined to limited areas, they were widely distributed in Texas, Louisiana and later in New Mexico and Arizona. Dr. W. D. Hunter was placed in charge of the eradication of this insect and the methods he and his associates later developed resulted in the eradication of this insect in those sections of Texas and Louisiana where it was first found. Altho there are a few isolated areas in which this insect is now found, inspection methods have been developed and control of cotton products in quarantined areas is such that the likelihood of this insect becoming established is not great. The accomplishment of the all but final eradication of this pest and the very efficient system of inspection initiated by Dr. W. D. Hunter and later developed by McDonald and others marks one of the major entomological accomplishments in this country. We pay tribute to the organizers and conductors of such activities. On the other hand many other men whose names will seldom ever be mentioned were as important in the prosecution of the work as were the directors, and have been as sincere in the performance of their duties, as efficient in doing their work, and as able in creating an attitude of confidence in the public. Study the history of the boll weevil work done by Dr. Hunter in 1904 and compare its reception with the cooperation which he received in 1917, and I believe you will agree that the various agencies at work, such as the Agricultural Colleges, The Extension Services, and the attitude and spirit of the men in entomological work during the interval had much to do in making it possible to put over and keep put over this difficult task in the face of much opposition.

On April 6, 1929, larvae of the Mediterranean fruit fly were discovered at Orlando, Florida. Due to the excellent organization of the State Plant Board of that state under Dr. Wilmon Newell, an efficient force of trained men were available to function in such an emergency. The Florida State Plant Board appealed to the Governor for permission to use the National Guard of Florida to throw a quarantine around the area in which the fruit fly had been found. These two conditions made it possible to put on a speedy and effective quarantine. On May 2, 1929, Congress approved a resolution, appropriating $4,250,000 for combating this insect. Thru the cooperation of the Plant Quarantine and Control Administration of the U. S. D. A. and the State Plant Board of Florida from 110,000 to 120,000 acres of groves were sprayed each week with the so-called "bait spray" thru July, August and September. Altho more than 1,000 properties were found to be infested, the insect was eradicated in a single season. Had this insect become established, its possibilities for damage to a considerable number of major crops in the southern and western states would have been unlimited. Thus one of the major fruit pests of the world was eradicated from a considerable area in a short time because the men who were directing this work had the confidence of the public, and this had much to do with enabling them to carry it to a successful conclusion.

The destructiveness of the Mediterranean fruit fly had been well advertised and as a consequence, a considerable part of the public was

informed of the possible damage this insect might inflict on agriculture. The effective organization of the Florida State Plant Board and the National Quarantine Administration furnished the means of combating this insect once funds were made available for that purpose by Congress.

Due to the preparation of the public mind thru the dissemination of proper information concerning the potential possibilities of this insect; and effective organization of quarantine officers and the vision of men who were willing to back their convictions, a second agricultural calamity to the South similar to that resulting from the introduction of the boll weevil was averted.

The boll weevil, pink boll worm, and Mediterranean fruit fly have been cited as examples of what might have been accomplished in the case of the boll weevil had the public mind been sufficiently prepared for the advice which was offered at that time and what has been accomplished in case of the pink boll worm and Mediterranean fruit fly thru the vision of men who have forseen the possible dangers.

The untiring efforts of the pioneers in entomological work in the South have done much to create confidence in the ability of the entomological fraternity to meet such emergencies. Other such emergencies will no doubt arise in the future. What can be done to create an atmosphere which will make possible the public support which is necessary for the successful prosecution of such work?

One of the important things is for research workers to aim at securing fundamental information. Much of our work in the past because of the necessity of obtaining adequate support has been conducted in a more or less indefinite manner hoping that by some lucky chance the right solution might be secured in a short time. Research work should be planned for a period of years so that all possible avenues may be followed out. The one lead left unexplored might prove to be the one which properly investigated might lead to the solution of the problem. The man who wants to "run from one problem to another" as a rule will not contribute a great deal to increasing confidence in entomological work. A mastery of the details of any problem can only be obtained thru long contact and arduous application.

There are several avenues thru which our agricultural colleges can do a great deal to acquaint the public with entomological work. The most important is the training of the right type of men for leadership. Many students come to these schools who are interested only in so called "practical courses." On that account they demand that our courses be made more and more practical. Courses of study may be made so practical that they are so threadbare that there is nothing left but the covering. If a student is to engage in scientific work or if he is going to assume a position of agricultural leadership, he should be made to acquire a fundamental knowledge of the subject. Only thru the acquiring of the fundamentals can he be made conscious of its purposes and real significance. It is one thing to acquire a few facts and quite another to acquire an attitude which recognizes the real import of the subject. Shortly after the eradication of the Mediterranean fruit fly the writer heard a graduate of one of our agricultural Colleges who was

on the scene make the statement that there never were any Mediterranean fruit flies in Florida. Such an attitude is usually a result of ignorance and not necessarily a malicious attempt to discredit the work being done. Nevertheless if the author of the statement had acquired the right attitude toward scientific work and entomological work in particular, such a position would have been untenable. In the future entomological information will to a great extent be conveyed to the public thru the agency of County Agents and Vocational Teachers of Agriculture. If these men have acquired the right attitude toward the fundamentals of our science, they will in turn make it possible for the public to realize the value of a program that can be developed over a period of years. If properly trained these men can also render entomological services which will be of great value to the communities in which they are located.

The youths of today are to be our leaders of tomorrow. The fostering of state and regional Contests in entomology under the guidance of Vocational Agricultural teachers should be of value in reaching part of our population who will never go to college. Altho these contests have not been conducted over a long enough period to evaluate their usefulness, the growing interest in them suggests this as one means of conveying reliable information to the public.

One phase of entomological work which has been neglected in the South is the development of insect collections. Many men who have collected in the South have sent their insects to the North or to some other country. Most of the Departments of entomology of the Agricultural Colleges and the Experiment Stations have developed and are developing insect collections. There are also some private collections of considerable size, but there has been neither the men nor the money available to develop insect collections to the extent that the conditions merit they should be developed. It should be the objective of every entomologist to assist in making it possible to develop the existing collections and create a public demand for their support and enlargement. Much has been accomplished along entomological lines in the South in the short period of the thirty-eight or forty years since the first entomological work was commenced. Because of present day economies, it may be necessary to curtail some of this work for a period of time, but the future holds much in store for entomologists of the South. Insects which have not been known to be of economic importance are appearing constantly, such as the cotton flea hopper and southwestern corn stalk borer. There remains much to be accomplished in taxonomic and ecological studies as well as in insect physiology. In the study of insecticides and biological control we have only begun. The solution of many important problems will depend on the resourcefulness of the entomologists. The elimination of malarial fever would work an important advance in the economic development of the south. The introduction of such pests as the boll weevil, pink boll worm, Mexican bean beetle, and Mediterranean bean beetle indicates that there is always a possibility of other insects obtaining a foot hold here. The awakening of the public mind to the possibility of other insects establishing

themselves ought to be an important object of future entomological work.

By extending a knowledge of insects thru our public schools, the extension Departments of our Agricultural colleges and the graduates of these colleges themselves, a greater service will be rendered to the public. The support obtained thru such services will assist in formulating better programs of research, aid in securing funds for establishing museums and better insect collections and the maintaining of quarantines to keep out insects which might be introduced from other countries or confining them within narrow limits if they have already been introduced. To coordinate all of these activities and make the South more conscious of the importance of entomological work in developing its resources should challenge our best efforts.

DISPERSAL OF THE PINK BOLLWORM BY FLIGHT OR WIND CARRIAGE OF THE MOTHS

By R. E. McDONALD, *San Antonio, Tex.*, and U. C. LOFTIN, *Washington, D. C.*, *Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

In the winter of 1918 a very light infestation of the pink bollworm (*Pectinophora gossypiella* Saunders) was discovered in the Big Bend area in Brewster and Presidio Counties, Tex., (Fig. 109.) This infestation extended for a distance of about 150 miles along the Rio Grande. At the time of its discovery it was believed that the infestation had been brought from the Laguna district of Mexico by the carriage of infested products, and an effort was made at eradication by cleaning all the fields and placing the area in a noncotton zone for the years 1919 and 1920. During the first year no cotton was grown on either side of the river except at Pilares, in the upper end of the area on the United States side, and this cotton was destroyed in mid-season after it was found to be infested. After two years the noncotton zone restriction was removed, and in 1921 plantings were made throughout the valley. Infestations were found that fall at practically all points in the Big Bend. There was no satisfactory explanation for this reinfestation, although various theories were advanced. A careful search was made for alternate host plants, but none were found. Consideration was given to the carriage of infested material by the rivers, but this did not account for the conditions that existed.

The infestation remained light until 1925, when there was a general increase, not only in the Big Bend, but throughout the valleys of the Rio Grande and the Pecos River in Texas and New Mexico. In that year a number of infestations were also found in small isolated cotton plantings in western Texas which were from 25 to 50 miles from previously infested areas. The recurrence of the pink bollworm in the Big Bend area after the application of eradication measures that had proved successful in several other places, as well as the infestations in isolated plantings, aroused the suspicion that adult moths reaching these points were the cause of the infestations.

It is well known that insects sometimes fly for great distances. The spread of the cotton leaf worm (*Alabama argillacea* Hbn.) from the Cotton Belt to the northern part of the United States and to Canada and the dispersal of the boll weevil over the Cotton Belt are familiar ex-

FIG. 109.—Location of trap plots used in the study of the dispersal of the pink bollworm.

amples of such flight among the cotton insects. The causes of insect migration are not known, but it appears to be due, in part at least, to a stimulus to search for food because of overpopulation or other unfavorable conditions. By "flight" or "migration" as used in this paper is meant either voluntary flight or involuntary carriage of moths by wind. Once the moths are aloft they are probably carried along more or less helplessly by the strong currents of the upper air.

As direct observations on flight would be difficult or impossible, the subject was studied at Presidio, Tex., and Tlahualilo, Durango, Mexico,

from several angles: (1) Airplane collections, (2) flight screens, (3) trap-plot plantings, and (4) wind movement. Some of the more important information contained in numerous unpublished reports on this work is summarized here. The work has been done by various agents of the Federal Horticultural Board, the Texas State Department of Agriculture, the Texas Agricultural Experiment Station, and the Bureau of Entomology of the United States Department of Agriculture. Special credit is due to Dr. F. A. Fenton, who was in charge of the pink bollworm laboratory of the Bureau of Entomology from 1927 to 1934 and planned much of the work. A summary of the early work and the importance of wind carriage of moths was published by Coad[1] and a paper by Fenton and Rude was read at the New Orleans meeting of the American Association of Economic Entomologists in 1931 but not published. The information in these two papers has been used freely.

If pink bollworm moths were migrating to the western part of the United States, the most logical source would be the Laguna district in Mexico, which is the largest and most heavily infested area in North America. This district lies about 200 miles south of the Big Bend section of Texas. The Laguna is a desert valley surrounded by mountains, which has been reclaimed by irrigation. A laboratory for the investigations of the pink bollworm was already established at Tlahualilo, on the northern edge of the district, and in 1928 a large series of airplane collections of insects in the upper air were made from there. The details of these collections will not be given here, but pink-bollworm moths were taken at all altitudes up to 3,000 feet above ground level. Experiments simulating certain conditions of moth isolation and exposure to temperatures comparable with those to which the moths were exposed in the upper air are reported by Noble.[2]

The prevailing wind at Tlahualilo is from the southeast. A wind-recording instrument installed in 1930 showed that more than half of the total ground movement was from this direction. Regardless of wind conditions at ground level, it was found in the airplane flights that a strong wind blowing from the south or southeast was always encountered at 1,000 to 3,000 feet above ground level (4,700 to 6,700 feet above sea level). The air over this desert and mountainous country was "rough" with strong convection currents, and such conditions are favorable for picking up and carrying insects. It is also of interest that the numbers of all insects caught in the upper air over the Laguna were much greater, per hour of flight, than at Tallulah, La.

FLIGHT SCREENS.—The first flight screens used were L-shaped frames covered with screen wire coated with sticky tree-banding material, as described by Fenton and Dunnam.[3] These were later modified by leaving a space for the air to pass between the panels. The screens were erected at Tlahualilo and Presidio with the panels facing north and

[1]Coad, B. R. Organization and Progress of Pink Bollworm Investigations. Jour. Econ. Ent. 22:743–750. 1929.

[2]Noble, L. W. The biological possibility of infestation by flight of the pink-bollworm moth. (For presentation and publication concurrently with this paper.)

[3]Fenton, F. A., and Dunnam, E. W. Dispersal of the cotton boll weevil, *Anthonomus grandis* Boh. Jour. Agr. Research 36:135–149, illus. 1928.

south or east and west, with the lower edges set about 3 feet above ground. One screen, erected 20 feet above ground, was operated for two years at Tlahualilo. Revolving screens which faced with or against the wind were also tested at both places. At Presidio the screens were erected within or near fields of plant cotton, while at Tlahualilo they were in fields of volunteer and plant cotton.

Daily readings of the screens were made most of the time. Boll-infestation records were made once a week and sweepings were made with a net three nights a week in cotton fields where the screens were located.

The screen records, sweeping records, monthly infestation, and rainfall are summarized in Table 1. Moths were caught on screens at Tlahualilo during the following periods: August 21 to December 16, 1928; August 10 to November 15, 1929; February 24 to November 5, 1930.

TABLE 1. PINK-BOLLWORM MOTHS CAUGHT ON FLIGHT SCREENS AND IN SWEEPINGS, BOLL INFESTATION, AND RAINFALL, AT TLAHUALILO, MEXICO, 1928–1930, AND PRESIDIO, TEX., 1928–1931

	Tlahualilo				Presidio			
Date	Average number of moths per screen[1]	Average number of moths per night in 100 sweeps	Average monthly boll infestation, per cent	Rainfall, inches	Average number of moths per screen[2]	Average number of moths per night in 100 sweeps	Average monthly boll infestation, per cent	Rainfall, inches
1928								
Aug.	0.4	—	69.5	1.23	—	—	0.11	0.80
Sept.	113.2	33.0	99.3	2.73	—	—	5.65	1.88
Oct.	212.0	31.6	100.0	0.00	3	1.23	40.15	0.64
Nov.	232.8	9.0	—	.06	—	—	59.96	1.15
Dec.	28.6	—	—	.00	—	—	—	.41
1929								
June	—	—	15.2	.12	—	—	—	—
July	—	—	30.5	.50	—	—	2.00	1.35
Aug.	4.3	—	71.8	.48	—	—	3.31	.62
Sept.	13.2	4.6	91.9	.66	0.2	2.97	22.59	1.83
Oct.	7.7	2.5	96.9	.54	1.0	3.73	42.59	1.65
Nov.	1.8	0.3	—	.15	.6	.25	51.38	Trace
Dec.	—	—	—	.08	—	—	—	.16
1930								
Feb.	0.5	—	—	.30	—	—	—	—
Mar.	0.7	—	—	.00	—	—	—	—
Apr.	3.2	—	—	.02	—	—	—	—
May	15.8	—	—	.54	—	—	—	—
June	18.8	—	41.3	1.27	—	—	—	—
July	13.1	—	65.4	1.84	—	—	2.20	1.81
Aug.	10.3	8.88	86.2	.65	—	—	4.08	1.03
Sept.	19.7	7.89	95.3	.36	1.43	2.91	25.75	0.00
Oct.	8.4	1.54	90.9	2.41	6.86	1.66	59.15	3.95
Nov.	5.3	1.33	—	.69	1.43	0.00	72.48	1.11
Dec.	.4	—	—	.15	—	—	—	.61
1931								
July	—	—	—	—	—	—	1.5	0.00
Aug.	—	—	—	—	—	—	8.0	0.00
Sept.	—	—	—	—	0.4	6.1	77.0	.30
Oct.	—	—	—	—	22.6	3.4	87.6	.28
Nov.	—	—	—	—	38.6	3.4	96.0	.70
Dec.	—	—	—	—	1.2	—	—	0.00

Summary of moths caught on screens

1928	587 moths per screen (5 screens operated Aug. 14 to Dec. 16)	3.0 moths per screen (7 screens operated Jul. 7 to Nov. 15)
1929	27 moths per screen (6 screens operated Aug. 1 to Nov. 15)	1.8 moths per screen (5 screens operated Jul. 30 to Nov. 15)
1930	105 moths per screen (6 screens operated Feb. 22 to Dec. 30)	9.0 moths per screen (7 screens operated Sept. 15 to Nov. 3)
1931	—	62.8 moths per screen (5 screens operated Sept. 10 to Dec. 4)

By far the heaviest catch was in 1928, the greatest number being in November, although many were also taken in September and October. September was the peak month in 1929 and 1930. The early records in 1930 were on screens in volunteer cotton fields, and these moths were from long-cycle larvae.

Screens were operated at Tlahualilo in 1931, but the results are hardly comparable with those of previous years. In order to reduce the pink-bollworm infestation, it was planned not to plant cotton on the main ranch in 1931. As a matter of fact, however, 30 acres were planted instead of the usual several thousand. The cotton stalks left from the previous year were plowed out during the winter, and some of the fields were planted to forage crops and some were left fallow. Four screens were operated during 1931 in fields that had been in cotton in 1930 and an average of 60 moths per screen were caught from January to July, the peak occurring during May. None were caught after July.

A planting of about 1,000 acres of cotton was made that year on land that had never been in cotton before, situated about 12 miles from the nearest cotton fields. Sterilized seed was used. Three screens in this new area caught an average of 28 moths each between July and October, the peak coming in September. By the end of September the infestation in this new area was practically 100 per cent, although this was reached later in the season and there were not quite so many worms per boll as in the old land. The infestation in the Laguna as a whole was above normal in 1931.

The records for 1928 to 1931 at Presidio (Table 1) show that small numbers of moths were caught from September to November, with the largest numbers during October. In 1931 the catch was very heavy, especially in October and November. The infestation in the Big Bend district and in the El Paso Valley increased greatly this year, and the damage was the worst ever recorded.

The catch at Tlahualilo was much heavier, began earlier, and lasted longer than at Presidio. It will also be noted that the field infestation began later in the season and increased less rapidly and uniformly at Presidio than at Tlahualilo. All the field records at Presidio show a light infestation until September and then a sudden increase. Furthermore, most of the worms found at the beginning of this increase have been small, indicating an increase in ovipositing moths at that time.

The fact that moths are taken on the screens does not necessarily prove that they are migrating, but the numbers taken do indicate moth activity in the fields and the months of greatest activity. The early-season catches were of moths developing from overwintered larvae and were much smaller at Presidio than at Tlahualilo. As was to be expected, the early-season catch was especially heavy in 1931 on the screens in fields at Tlahualilo where there was no cotton. In all the records for both localities, however, the greatest numbers of moths were taken in the fall after the infestation had become rather heavy. On similar screens the catch of boll weevils is always much greater during the fall after general field movement and migration begin. The number of pink bollworm moths taken on the screens at Tlahualilo during the peak

months was greater than the number of boll weevils usually caught at Tallulah, La., during the migration period.

The relative numbers of moths taken on the screens facing different directions varied greatly, but in general were greater on the north and south panels than on those facing east and west. The revolving screens were not entirely satisfactory, and the numbers of moths taken were too small for conclusions to be drawn, although in 1930 about twice as many were taken on the side facing the wind at Presidio. In general the screen catches indicate a dispersal in all directions, and the numbers taken on the panels facing the cardinal directions showed little correlation with the direction of the ground currents. Moths were taken on the screens set 20 feet above the ground, but the figures are not available.

The sex was determined for all moths caught on the screens during two years. In 1930, 48 per cent of the moths at Presidio and 41 per cent at Tlahualilo were females. In 1931, 28 per cent at Presidio and 52 per cent at Tlahualilo were females, or an average of about 42 per cent females for all moths of which the sex was determined. In a sample of 50 females from screens examined at Tlahualilo in 1931, 72 per cent contained mature eggs.

TRAP PLOTS.—The typical trap plot used was a small planting of 50 to 100 cotton plants in an isolated spot. In a few plots okra was planted instead of cotton.

The first trap plots for determining pink bollworm dispersal were reported by Ohlendorf[4] from Mexico in 1921 and 1922. Infestation occurred in the most distant plot, which was 40 miles from cotton, but it was not certain that live larvae had not been brought in by passing Mexican families. Ohlendorf also found no significant difference in the infestations in cotton fields ranging from 0.6 to 3.7 miles (1,000 to 6,250 meters) from infested cotton fields of the previous year.

More carefully controlled conditions were possible in Texas, and a series of trap plots were planted during the six years 1926–1931. The plots were located in the western Texas ranch country as far as possible from the main highways and cotton fields. Seed definitely known not to be infested was used, and every effort was made to see that there was no introduction of pink bollworms to the plantings. From 1928 to 1931 each plot was visited about three times a month, and all bolls large enough to be infested were removed. In this way the dates of infestation could be determined very closely.

The location of the trap plots, the distance from the nearest cotton, and the date when infestation was found are shown in Figure 109 and Table 2. Of the 90 plots under observation during the 6 years, 18 became infested. None of the plots became infested in 1926, whereas 8 of the 9 plots were infested in 1927. For each of the other years 2 or 3 plots were infested. Except for 1927, when no records were made until late in the season and the date of infestation is not known, all the plots are known to have become infested from late in September to November,

[4]Ohlendorf, W. Studies of the pink bollworm in Mexico, U. S. Dept. Agr. Dept. Bull. 1374, 64 pp., illus. 1926.

TABLE 2. LOCATION, DISTANCE FROM NEAREST COTTON FIELDS, AND INFESTATION OF TRAP PLOTS, 1926 TO 1931

County	Ranch	Location	Nearest cotton fields	Infestation 1926	1927	1928	1929	1930	1931
		Van Horn Section:							
Culberson	W. T. Medley-Newton	4 mi. SE. Van Horn	35 mi. S.	No	Yes	Nov. 13	Oct. 22	No	Sept. 30
		Valentine Section:							
Jeff Davis	Wilkins-Road Station	2 mi. NW. Valentine	25 mi. SW.	No	Yes	No	No	——	——
	Youngblood	4 mi. SE. Valentine	20 mi. S.	No	——	——	——	Nov. 3	Oct. 28[1]
	Kelley-Gleim Espy	15 mi. NE. Valentine	30 mi. S.	No	Yes	No	No[1]	Nov. 3	No[1]
		Pt. Davis Section:							
	O. Medley	20 mi. E. Valentine	40 mi. S.	——	Yes	No	No	No	No
	Merrill	9 mi. SW. Ft. Davis	70 mi. S., 40 mi. N.	——	——	No	Oct. 8	Oct. 29	No[1]
	Huelster	10 mi. S. Balmorhea	75 mi. S., 7 mi. N.	——	——	No	No	No	——
	Nunn	18 mi. SW. Balmorhea	75 mi. S. 15 mi. NW.	——	——	No	——	——	——
		Alpine Section:							
Presidio	Mitchell-Paisana	12 mi. W. Alpine	60 mi. S.	No	Yes	Oct. 7	No	——	No
Brewster	West	6 mi. W. Alpine	60 mi. S.	No	Yes	——	——	——	——
	Yates	2½ mi. SW. Alpine	60 mi. S.	No	——	——	——	——	——
	Arnold	2 mi. SE. Alpine	60 mi. S., 60 mi. N.	——	——	——	——	——	Nov. 10
	Merriweather	12 mi. E. Alpine	60 mi. S.	No	——	——	——	——	——
		Marathon Section:							
	Gage	8 mi. SW. Marathon	65 mi. S.	No	Yes	No	No[1]	No	——
	Spruce	2½ mi. SW. Marathon	70 mi. S., 60 mi. NW.	——	Yes	No	No	No	No
	Hudspeth	2½ mi. S. Altuda	70 mi. S.	——	No	——	——	——	——
		Sanderson Section:							
Terrell	Carpenter-Crow's Nest	17 mi. N. Dryden	65 mi. NW.	——	——	No	No	No	No
	Banner	45 mi. N. Dryden	65 mi. W.	——	——	No	No	No	No
	Chandler-Goldwire	5 mi. N. Sanderson	65 mi. W.	——	——	No	No	No	No
		Pt. Stockton Section:							
Pecos	Edwards	46 mi. N. Sanderson	45 mi. NW.	——	——	No	No	No	——
	Rochelle	35 mi. SE. Ft. Stockton	35 mi. N.	——	——	No	No	No	No
		Balmorhea Section:							
Reeves	Moore	12 mi. NE. Balmorhea	6 mi. W.	——	——	No	No	No	No
	U	15 mi. SE. Balmorhea	12 mi. NW.	——	——	No	No	No	No
	Phantom Lake	8 mi. SW. Balmorhea	9 mi. NE.	——	——	——	——	——	No
		Monohans Section:							
Ector	Goodman-Cowden	18 mi. NW. Odessa	8 mi. SE.	——	——	No	No	No	No
Winkler	Ragsdale	6 mi. N. Monohans	30 mi. E.	——	——	No	No	No	——
Ward	Key	4 mi. E. Barstow	4 mi. W.	——	——	——	——	——	No
				——	——	——	——	——	——
		Total number of plots		9	9	19	18	18	17
		Number of plots infested		0	8	2	2	3	3

[1]Planted to okra.

after the moths became abundant in the fields and were taken in numbers on the screens. In all the plots that were examined regularly only small larvae were present when first found, an indication that the infestation was of recent origin. In some of the plots practically all the bolls became infested late in the season. Some of the infested plots were 65 miles from the nearest cotton. Plots located near the lightly infested areas in the Madera Valley around Balmorhea, Tex., never became infested. The plots in the Van Horn section became infested in 4 of the 6 years and none of the plots east of Marathon were ever infested.

Infestation by the leaf worm occurred in some of the plots each year and was not confined to any one section. Boll weevils were also found in 1928 and 1931, but only in the plots in Terrell and Pecos Counties at the eastern edge of the district nearest to infested cotton fields.

WIND MOVEMENT.—The distinct localization of infestation in the trap plots and the history of the infestations in the Big Bend and other areas to the north and northwest of the Laguna could not be satisfactorily explained by accidental carriage of infested material or by voluntary flight of the moths, as it is not likely that either of these movements would be in only one general direction. This, together with the infestation in the trap plots and the rapid increase in the field infestation occurring after the dates when the most moths were taken on the flight screens, indicated that moths were coming from the Laguna.

All the country we are discussing is mountainous. The Laguna lies between the eastern and western ranges of the Sierra Madre Mountains, which extend in a general southeasterly to northwesterly direction. Near the border on both sides of the river and in Brewster, Presidio, Jeff Davis, and Hudspeth Counties are numerous high peaks. The weather records for a 5-year period from several stations in western Texas showed that the general movement of ground currents between the Pecos River and the Rio Grande was parallel to the direction of the rivers, which is the same general direction of wind movement as in the Laguna. It would be expected that the spread of infestation would be with the general wind movement and not crosswise. The distribution of infestation in both trap plots and fields shows that this is just what has occurred. During the years before and after the trap plantings were made, cotton was being planted in Mexico and Texas east of the Sierra Madre Mountains, some of which was no farther from the Laguna than the Big Bend. Furthermore, the cotton in the Lower Rio Grande Valley of Texas and Mexico is but little farther from the Laguna than the Big Bend. Except for the infestations in the San Carlos-Monclova area of Mexico, which did not remain permanent, no infestation was ever found in these plantings. On the other hand, the extensive cotton areas in the Pecos and Rio Grande Valleys of Texas and New Mexico have remained infested.

The amount of wind movement and pink bollworm conditions in the Laguna show some interesting relationship to the spread and intensity of infestation in the southwestern part of the United States. One of

the measures used for intensity of pink bollworm infestation in the United States has been the number of worms found per man-day of scouting from November to February on the Ivy Dale Ranch in the El Paso Valley of Texas. Records are available from 1920 to 1931, when examinations by gin-trash machines were substituted for scouting. A

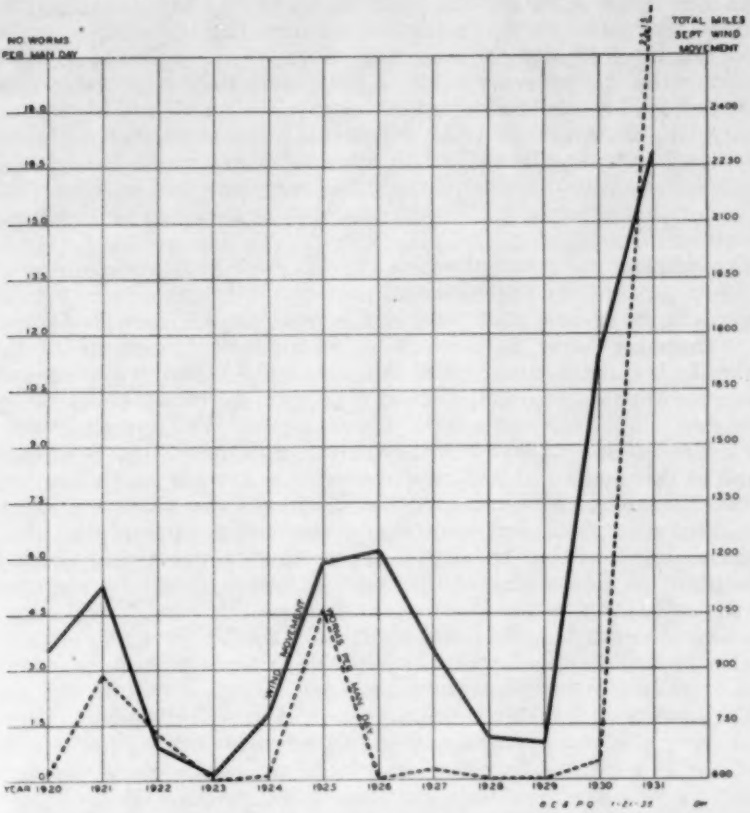

FIG. 110.—Comparison of the number of pink bollworms found per man-day of scouting in Ivy Dale Ranch from November to February, with the total number of miles of ground wind movement at Tlahualilo during September, 1920–1931.

comparison of the total ground wind movement at Tlahualilo during September, the month when heavy screen catches began, with the number of worms found per man-day of scouting at Ivy Dale ranch is shown in Figure 110.

The curve for the number of worms follows that of wind movement very closely. In 1920 and 1925 the infestation in the Laguna was very heavy. The first infestation on the Ivy Dale ranch was found in 1920. Following the heavy infestation of 1925 in the Laguna, a large quan-

tity of irrigation water was received later than usual in the winter of 1925–26 and almost all the Laguna cotton fields were irrigated. This apparently killed most of the overwintering larvae, for the infestation was still low when a leaf worm invasion in September 1926 completely defoliated the plants and checked breeding. The September wind movement for 1926 was the highest recorded up to that time, but there were comparatively few moths in the Laguna and the Ivy Dale infestation remained low and none of the trap plots became infested. The September wind movement for 1927, 1928, and 1929 was low, while in 1930 and 1931 it was the highest on record. The number of worms found at Ivy Dale increased in 1930, and in 1931 was more than eight times the highest previous record. The infestation in the El Paso and Big Bend Valleys also increased greatly in those years and in 1931 was the highest it had ever been. The infestations in the trap plots remained the same.

The weather maps for the falls of 1927 and 1933 also showed low-pressure areas in the north-central part of the United States which remained more or less stationary for several days. These low-pressure areas caused a diversion of normal wind movement from up the Pecos Valley to the northeast, toward the so-called "Western Extension" in Howard, Martin, Midland, Ector, Andrews, Dawson, and Glasscock Counties. Pink bollworms were found in the Western Extension in 1927. Eradication measures were applied, and only a few worms were found in this area until 1933, when there was another general outbreak, involving several additional counties. There was also a heavy infestation at Castolon in 1927, but control measures were applied and the infestation remained low until 1933. It seems reasonable that the heavy infestation at Castolon and the wind diversion might be responsible for the infestation in the Western Extension. The wind blowing up the Rio Grande from the Big Bend to the El Paso Valley probably carries moths from both the Laguna and the Big Bend, especially from the Big Bend, since the infestation has been heavy during recent years.

The history of the infestations, the airplane collections, flight-screen catches, trap-plot plantings, and wind movement made it seem certain that moths were reaching the United States largely from the Laguna. It is also quite probable that these migrating moths were the principal source of infestation in the United States during the early years. However, after the infestation had increased in the Big Bend until there were considerable numbers of worms surviving the winter, it is believed that the local moths and local wind movement also played a part in dispersal.

Factors Influencing Migration.—The weather records, field-infestation records, and flight-screen records (Table 1) indicate some of the factors influencing migration. In some instances rainfall seemed to stimulate moth activity, as shown by the screen catch, and in other cases it did not. This was particularly true at Tlahualilo. A storm at Tlahualilo from September 20 to 26, 1928, with 2¾ inches of rain, greatly increased the number of moths on the flight screens. Between September 1 and 20, 125 moths were taken, while during the remainder of the month 441

were taken, and the catch remained high through October and November. In 1929 several small showers, totaling 1½ inches of rain, during the period the screens were operated did not noticeably increase the catch. In 1930, 42 of the 95 moths caught in May were taken on the 26th and 27th following half an inch of rain, and 94 of the 113 moths caught in June were taken on the 8th and 15th when an inch of rain fell. In laboratory tests an application of water to soil containing pupae did not hasten their emergence. As there was no lag between the increased catches and the rains, the increases seem to be due to stimulation of the moths already present. An analysis of barometric pressure, temperature, total rainfall, and wind velocity has failed to show why rainfall in some cases failed to stimulate migration.

With the exception of the moths coming from the overwintering larvae, large numbers were never taken on the screens or by sweepings until the field infestation was high. The peak of the catch on both screens and sweepings was always in the fall of the year and later in the season at Presidio than at Tlahualilo, as was the increase in field infestations. This indicates that migration of moths from the short-cycle or summer larvae is greatest from fields where there is an excess population of moths, and perhaps a shortage of food. If this is true, control measures to reduce the infestation and keep it from reaching the saturation point will also reduce the danger of spread.

SUMMARY.—Information on the dispersal of the pink bollworm by flight or wind carriage of moths was obtained by means of airplane collections, flight screens, trap plots, and wind movement. Moths were taken in airplane collections up to 3,000 feet above ground level and in large numbers on the flight screens. Some of the trap plots located from 25 to 65 miles from the nearest cotton became infested late in the season in 5 of the 6 years planted.

The prevailing wind is from the heavily infested Laguna district of Mexico toward the United States, and the areas infested in the western part of the United States are in the general direction of the wind currents. The total wind movement in the Laguna during September 1920 to 1931 was closely correlated with the intensity of infestation in Texas. All the indirect evidence indicates that the pink-bollworm moths fly or are carried involuntarily by the wind for considerable distances.

PRELIMINARY REPORT ON COTTON ROOT APHIDS IN SOUTH CAROLINA

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It has been known for many years that root aphids do more or less serious injury to seedling cotton in the Coastal Plains section of the Carolinas. The first reports of injury to cotton by root aphids were from North Carolina in 1902 or 1904.[1] Later reports of similar in-

[1]Determinations of the aphids discussed in this paper were made by Dr. P. W. Mason, Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

jury came from South Carolina in 1908. The species of root aphid causing the injury in South Carolina was determined at that time as *Anuraphis maidi-radicis* Forbes, previously confused with *Aphis maidis* Fitch and since 1862 commonly called the corn root louse.

Investigations of the damage done to cotton by this root aphid were begun in Marion County, S. C., in 1909. The work was started by W. A. Thomas and continued by G. G. Ainslie, and the results of their work were published in the 22nd Annual Report of the South Carolina Agricultural Experiment Station by A. F. Conradi (*1*). At that time, and until the author began his investigations in April 1934, it was assumed that only one species of root aphid was involved, this being *Anuraphis maidi-radicis*. Investigations throughout the spring and summer of 1934, however, showed that three species were responsible for the damage to cotton in South Carolina; these being *A. maidi-radicis*, *Trifidaphis phaseoli* (Pass.), and *Rhopalosiphum* sp.[1] Any one of these species is capable of causing severe injury to the young cotton plant, and instances were observed of cotton plants completely killed and the stand of cotton materially reduced by each of the three species.

The common name "cotton root louse" has previously been considered as referring only to *A. maidi-radicis* when attacking the roots of cotton. Since three species of root aphids are involved, however, and since this common name is confusing and inadequate to indicate any one of these species separately, the author has found it convenient to refer to *A. maidi-radicis* as the green cotton root aphid, to *T. phaseoli* as the white cotton root aphid, and to *Rhopalosiphum* sp. as the brownish-purple cotton root aphid. These common names, based on their colors, describe each species sufficiently to prevent confusion when any one of them is referred to separately.

The green cotton root aphid, *A. maidi-radicis*, was found to be the most widely distributed of the three species. Although these investigations were confined chiefly to Florence County, occasional observations in Darlington, Lee, Dillon, Marion, Williamsburg, and Dorchester Counties showed that it is present in all these counties. It doubtless occurs throughout the entire eastern and central parts of South Carolina, particularly on the finer types of sandy soils, where it was always found more abundant. The damage caused by this species ranged from an occasional stunted or dwarfed plant in a field to rows several yards long where the plants were completely killed. This root aphid was first found on the roots of cotton about May 15 and was present there until about July 20. After this date and until about December 10 it was found on the roots of various weeds and other crops.

The white cotton root aphid, *Trifidaphis phaseoli*, has not previously been reported from cotton in the United States, but it is recorded from the roots of sweet peas (4, p. 374) and beans (2, part III, p. 240). It is known to occur in Italy, France, Egypt, and England, having been reported from the last country on the roots of beans, turnips, grasses, and on potato and gladiolus bulbs (*5*). In Egypt it attacks the roots of tomato, tobacco, wheat, and barley; and, as reported by Hall (3, p. 47), Willcox refers to a heavy attack at Gezireh on the roots of seedling

cotton in 1921. This species was found only in Florence, Darlington, and Marion Counties. It was found on the roots of cotton the first week in May and continued to be present in destructive numbers until the first week in July. At that time it completely disappeared and was not found later, even on wild hosts. It occurred earlier in the season and in greater numbers on the roots of individual plants than either of the other species. Hence, the resulting damage was greater in places where it did occur, owing to the larger colonies per plant, than that caused by either of the other species. The injury was not so widespread as that from *A. maidi-radicis*, however, and the total damage, therefore, was not so great.

The brownish-purple cotton root aphid (*Rhopalosiphum* sp.) was first determined by Dr. Mason as "either a five-segmented strain of *Rhopalosiphum* or a new genus." There is considerable doubt as to its identity, and further investigations may prove it to be new. No references to the occurrence of any species of the genus *Rhopalosiphum* on the roots of cotton were found. Gillette and Palmer (2, part II, p. 478), in characterizing the genus, state that it was found "living exposed on leaves and twigs of plants." This species was found only in Florence and Darlington Counties, but as not over 5 per cent of all the observations were made outside of Florence County, the absence of a species from the other counties in which but few observations were made is by no means an indication that it is not present. It was found in scattered colonies on the roots of cotton in the second week of May and was found occasionally throughout June. Its occurrence on the roots of cotton was rather spotted in a few fields, but in places where it did occur considerable damage was done. The worst injury by this species, however, was to okra and butter beans. In one small field 40 per cent of the okra was killed by it, and a slightly lower percentage of butter beans in this same field was killed.

The actual amount of injury to cotton by these three species of root aphids is hard to estimate. The total percentage of plants killed in localities where root aphids occur is relatively small; although observations were made in some badly infested fields where one-third or more of the seedling cotton was killed. The actual killing of the plants more often occurs before the cotton is chopped; however, a number of cases were observed where plants that had been chopped were later killed. It is easier for the aphids to be carried from one plant to another on unchopped cotton, however, and from the point of an initial infestation on a given row the tendency is for the kill to go in succession, plant by plant, lengthwise of the row, oftentimes leaving places several yards long in which every plant has been killed. But perhaps the greatest injury caused to cotton by root aphids is the stunting or dwarfing of the plants immediately following the chopping period. This is the time in which it is highly desirable to have the plants growing as rapidly as possible, but when root aphids are present the plants are stunted, turn yellow, and make but very little growth. Sometimes the infested plants overcome the aphid attack and grow into normal plants after being considerably delayed, but often they die. Heavily infested fields

are more easily recognized at this stage in the growth of the cotton than at any other time, uninfested plants being much taller and healthy looking.

There are a great number of host plants other than cotton from which these root aphids have been taken. Table 1 shows the different plants from which each of these species of root aphids was taken.

TABLE 1.—HOST PLANT RECORDS OF *Anuraphis maidi-radicis*, *Trifidaphis phaseoli*, AND *Rhopalosiphum* sp. IN THE COASTAL PLAINS AREA OF SOUTH CAROLINA

	Anuraphis maidi-radicis	Trifidaphis phaseoli	Rhopalosiphum sp.
Cotton	x	x	x
Corn	x		
Soybeans	x	x	
Okra	x		x
Butter beans	x		x
Field peas		x	
Cocklebur	x	x	
Chenopodium album	x	x	
Gnaphalium purpureum	x		
Richardia scabra	x		
Crotalaria	x	x	
Smartweed	x		
Croton	x		
Eupatorium capillifolium	x		
Carara didyma	x		
Plantago aristata	x		
Erigeron canadense	x		
Amaranthus hybridus	x		
Chenopodium ambrosioides	x	x	
Ragweed	x		
Amaranthus spinosus	x		
Erigeron ramosus	x		
Diodia teres	x		
Heterotheca subaxillaris	x		
Oenothera sp. (*biennis?*)	x		
Isopappus divaricatus	x		

The above is only a partial list of host records already made. Positive determinations of the root aphids taken from several other plants have not been made, and therefore the occurrences can not be included in this table. Doubtless many other records can be added later.

Seven species and varieties of ants, listed in Table 2, were found to be attending the root aphids of cotton. Of this number, however, only two were found to be nearly always present with the aphids. These

TABLE 2.—SPECIES AND VARIETIES[1] OF ANTS COLLECTED IN ATTENDANCE ON THE DIFFERENT SPECIES OF COTTON ROOT APHIDS STUDIED

	Anuraphis maidi-radicis	Trifidaphis phaseoli	Rhopalosiphum sp.
Pheidole vinelandica Forel	x	x	x
Lasius niger L., var. *neoniger* Emery	x	x	x
Solenopsis molesta Say	x		
Lasius (*Acanthomyops*) sp	x		
Pheidole sp	x	x	
Dorymyrmex pyramicus Roger	x		
D. pyramicus, var. *flavus* Pergande	x	x	

[1]Determinations of the ants discussed were made by Dr. M. R. Smith of the State Plant Board of Mississippi.

were *Pheidole vinelandica* and *Lasius niger* var. *neoniger*, which were usually found together. The remaining species and varieties occurred only occasionally.

Observations on life history and development under insectary conditions were made of each of the three species of aphids discussed above; although only a very few detailed records on life history were made of the green cotton root aphid, *A. maidi-radicis*, and the white cotton root aphid, *T. phaseoli*, as they are delicate and hard to handle without injuring them. The method used in making these observations was to place each individual on a sprouted seed of cotton in a small shell vial, stop the mouth of the vial with a piece of absorbent cotton, and place it in a convenient-sized hole bored in a wooden block. The hole was small enough in diameter for the vial to fit in snugly and deep enough to exclude all light. The cotton seeds were sprouted out of doors in warm weather, but in cool weather they were sprouted in a temperature-controlled oven at about 90°F. When the sprouted seeds were removed from the soil they were washed clean and placed in a tumbler of water until ready for use. This kept them from becoming dry and shriveled. As each sprout was removed from the tumbler, it was wiped dry with a piece of cheesecloth. A camel's hair brush was used in placing the aphids on the sprouts, and extreme care was necessary in doing this. The young nymphs especially are very easily mashed, or if they are left adhering to the sprouts on their sides or backs they will die in this position. Before placing the vial in a hole in the wooden block it was necessary to be sure that the specimen was able to move about on the sprout. Each specimen was examined daily under a binocular microscope, the cast skins removed, data recorded, and the specimen again placed on a fresh sprouted cotton seed. This method was used for determining both the developmental periods of the nymphs and the productiveness of the adults.

The white cotton root aphid is the least active of the three species studied. It is almost helpless by itself. The first-instar nymph is fairly active, but with each successive instar it becomes less so, and if the adult gets on its back it will die without being able to turn over. It is dependent entirely on the attending ants for its existence. It is negatively phototropic, but positively geotropic and thigmotropic. The reactions to all these stimuli are carried to the extreme in this species, and their combination makes it difficult to observe their life history. It is almost impossible to rear specimens singly in vials. They will not remain placed on the sprout where they can feed, but will go to the bottom and adhere as closely as possible to the side of the vial.

The green cotton root aphid is considerably more active than the preceding species, but is less active than the brownish-purple cotton root aphid. It is also gregarious, but it can be segregated and reared singly according to the method explained above. It is very delicate and extreme care must be taken in removing it from, or placing it on, the cotton sprouts. It is also negatively phototropic, but positively geotropic and thigmotropic although not so much so as the white cotton root aphid. Occasionally it molts five times before becoming adult, but

in nearly all cases there are only four molts. The average length of time spent in the different instars, based on data from 13 specimens born from June 10 to June 24, is as follows: First, 1.92 days; second, 1.77 days; third, 1.61 days; fourth, 1.70 days, fifth (one specimen), 1 day.

The brownish-purple cotton root aphid is very active in all stages. It is also negatively phototropic, but the geotropic and thigmatropic stimuli are manifested to only a very slight degree. In their natural habitat they are gregarious, but they can be reared singly with ease and are not at all delicate as are most other aphids. Detailed life-history records were made of this species through 24 consecutive generations between June 14 and December 1. They usually molt four times, but occasionally they molt five times. The average length of time required for nymphal development through the 24 generations was 6.56 days at an average mean temperature of 78.8°F. The average life of the adults was 8.1 days at an average mean temperature of 76.4°F. The adults produced an average of 4.4 nymphs per day, or an average total of 35.6 during life.

SUMMARY.—Three species of aphids, *Anuraphis maidi-radicis*, *Trifidaphis phaseoli*, and *Rhopalosiphum* sp. were found injuring the roots of cotton in the Coastal Plains section of South Carolina in 1934. Notes are given on the distribution, damage, host plants, and biology of the three species.

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EFFECT OF THE 1934 DROUGHT UPON THE BOLL WEEVIL[1] IN OKLAHOMA

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During the crop growing season of 1934 a drought of unprecedented proportions affected Oklahoma. So severe was the combination of lack of rain and excessively high temperatures, that cotton, ordinarily considered a drought resistant plant, was very seriously damaged. The injury ranged all the way from a stunted determinate growth, shed fruit and undersized bolls, to actual browning of the plants in many fields. The cotton boll weevil, *Anthonomus grandis* Boh., is a pest that

[1] *Anthonomus grandis* Boh.

thrives in cloudy or wet weather so it was of interest to determine what effect the drought had upon this insect. A combination of circumstances made such a study particularly opportune. The preceeding winter had been mild with minimum temperatures recorded of 15°F. for the southeastern section of the state, 12°F. for the east central section and 7°F. for the northeastern section. Conditions were therefore favorable for a high weevil survival at least in the southeastern section. Field counts made from late May to late June 1934 showed a very high overwintered weevil population present in the fields of young cotton. This population was considerably in excess of that recorded for the previous three years and was sufficient to cause fear that 1934 was to be a year of very severe boll weevil damage. June 21, there was an average of approximately 344 weevils per acre based upon counts made in nine fields. A week later in three of the four fields sampled there had been a marked increase of the weevil population. Probably no better opportunity could have been presented to show how important the factor of summer climatic conditions can be upon the boll weevil.

Review of Climatic Conditions.—The boll weevil causes its greatest damage in the southeastern part of Oklahoma. From this section the seriousness of the infestation may extend northwards and westwards, depending largely upon climatic conditions in these sections. Therefore, only the climate of eastern Oklahoma is considered in this paper. This section of the state was divided into three parts for this study, namely, the southeastern, central eastern and northeastern. Three localities were selected in each section and the monthly rainfall averaged for each. The most striking feature was the marked deficiency of rainfall every month except September and November for the entire eastern section of the state. There was a slight excess over normal in March for the southeastern section and for January for the other two sections.

The months of May to August inclusive can be considered as the critical period in this case. The total rainfall for this period for the southeastern section was 4.6 inches which was less than that recorded for the other sections. The deficiency was 12.3 inches for these months in the southeast and ranged from 8.3 inches to 8.6 inches for the other two sections. It is rather difficult to correlate mean maximum air temperatures with possible high weevil mortality. Absolute maximum air temperatures, however, tell a more significant story. Although these temperatures in themselves are not fatal to the boll weevil, their effect is to heat the surface soil, particularly if it is dry, to excessively high temperatures. Surface soil temperatures sufficient to cause high mortality of weevil stages in fallen squares were reached almost daily for a period of approximately two months as the following data show. The actual peak of the heat wave began June 20 and extended through August 21. Maximum temperature records during this period were obtained for eight locations in the eastern section of the state. Only temperatures from 100 and up were considered. At one location 61 out of 73 days had maximum temperatures of 100°F. or above. Temperatures as high as 112°F. were recorded in two cases with the greatest frequency at 101°F. and 105°F.

EFFECT OF DROUGHT UPON WEEVIL MORTALITY.—The effect of the above combination of climatic conditions was to accelerate shedding of fruit on the cotton plants and to kill most of the immature weevils in fallen squares and young bolls on the ground. Examinations of shed and dead attached squares and young bolls during August and early September showed that few immature weevils were surviving. On August 11 and 13 over 2,000 hanging and fallen dead squares and bolls were examined in two representative fields. The mortality due to heat ranged from 77.5 per cent to 83.97 per cent in the fallen forms and from 33.3 to 53.98 per cent in dead hanging forms. The cotton in the field having the lower mortality was a broad leafed variety with a fairly rank growth thus giving maximum shade protection. This same variety also had a tendency to retain a comparatively large proportion of its dead forms. Both fields were situated in rich bottom lands and the rank growth of the plants gave the maximum protection possible from sunlight and heat. The average conditions were much more severe for the boll weevil, especially in fields in the uplands where the excessive heat caused extensive shedding of leaves. These figures show that even under the most optimum conditions there was a very high weevil mortality due to heat. The total mortality due to parasites and other causes in these fields for the above dates ranged from 70.5 per cent to 91.03 per cent. Records taken subsequent to these showed a continuation of high mortality in fallen forms until September first when a marked drop was observed.

EFFECT OF DROUGHT UPON WEEVIL INFESTATION AND COMPARISON OF WEEVIL INCIDENCE WITH FORMER YEARS.—The comparative abundance of the boll weevil during late May and June from 1931 to 1934 is shown in Table 1. The weevil certainly had a good start in 1934 over the preceeding three years. These figures should be compared with the comparative percentages of square infestation shown for these years in the same table. The small weevil population of 1933 was followed by a light infestation for that year. The larger early weevil population in 1932 was followed by a much higher average percentage of infestation that year and it continued to increase steadily as the season advanced. Therefore it would be expected that the large early weevil population in 1934 would have been followed by an usually early high percentage of infestation. Instead, however, the situation was very markedly reversed from 1932. The first three counts in 1934 showed that the percentage of infestation was being maintained at a fairly high level. These records indicated that overwintered boll weevils were still in sufficient abundance in the fields to keep up the percentage of infestation. This was prior to the beginning of the heat wave. Late in June, however, the infestation began to drop and this continued to be the trend up to mid-July. The slight increase recorded after that is not significant because the plants were carrying very few squares which the few surviving weevils were puncturing. Only the hardiness of the overwintered weevils and their comparatively long period of activity kept the species alive in the cotton fields.

CAUSE OF THE INCREASE IN WEEVIL POPULATION IN LATE SUMMER.—In early August there were too few squares in the fields to count, so it was decided to determine boll infestation and to dissect infested bolls to ascertain the comparative ratio of the different immature weevil stages in them. These records were continued until early September when most of the green bolls had opened (Table 2). The average of green boll infestation remained at approximately 23 per cent for this period. Many of these bolls had received egg deposition while still small, probably most of them by first brood weevils which turned to the bolls after squares began to become scarce. Fenton and Dunnam[2] have shown that most of the late egg deposition by first brood weevils is in bolls since squares usually become scarce during the period that this brood is active. Also some egg deposition in bolls is possible by late surviving overwintered weevils. In a year such as 1934 in Oklahoma, excessive cotton shedding due to drought conditions caused a scarcity of squares much earlier than usual with the habit of egg deposition in bolls coming into play earlier. It has also been shown that weevil development in bolls is retarded over that in squares. In South Carolina[3] it averaged approximately 32 days, the maximum record being 94 days.

The first examination of infested bolls early in August showed that most of the weevils were still immature. There were 91.8 per cent of them in the larval stage, 6.6 per cent were pupae, 1.6 per cent were adults and none had emerged. Inasmuch as the infested boll is usually not shed by the plant unless it is only a few days old when infested, it was apparent that the weevil was largely surviving the drought by the habit of ovipositing in green bolls when squares become scarce. Records taken by Fife[4] show that the boll temperatures do not exceed air temperatures sufficiently for lethal temperatures to have been produced in these bolls.

A weekly examination of the infested green bolls showed what was happening. The percentage of weevils in the larval stage decreased until late September while the percentage of adults increased steadily. Compare these figures with those on weevil population in these fields (Table 2). There was an average of 250 weevils per acre August 15. This was smaller than that recorded in one of the fields in June. The weevil population increased very rapidly after this date, reaching the peak of approximately 1100 per acre when the last two counts were made. These records show that the weevil was able to at least hold its own throughout the drought very largely because of its habit of egg deposition in green bolls. Since these were retained by the plant and remained green and succulent, the immature stages were not killed by the heat. At this time, as previously shown, most of the immature weevils in shed forms and a considerable proportion of them in dead attached forms, were being killed by high temperatures. The delayed

[2]Fenton, F. A. and Dunnam, E. W. Biology of the Cotton Boll Weevil at Florence, S. C. U. S. D. A. Tech. Bull. 112. 1929.

[3]Fenton, F. A. and Dunnam, E. W. op. cit.

[4]Fife, L. C. Temperature Studies in a Cotton Field, Presidio, Texas 1932. Ecology XV. No. 3. 298–305. 1934.

development of weevils in bolls caused the emergence of weevils from them to start in mid-August or about the time the heat wave began to subside. Temperatures about that time dropped very sharply all over the state because of rains. In the fields sampled very little rain fell, but in general September was a month when rainfall was above normal and the total precipitation was greater in the east central and northeastern sections than in the southeastern section.

HEAVY RAINS IN AUTUMN FAVOR WEEVIL INCREASE.—Although October rainfall was scant, there was a further excess over normal in November. Furthermore frost came very late in the latter month. Thus cotton was able to start fruiting again. This provided an abundance of squares so that weevils were enabled to enter hibernation in good condition. In addition, a supplementary fall generation was produced in these late squares. While no field counts were made, the actual numbers produced were far in excess of the figures given as representing the number per acre in September. Nevertheless, despite a late and favorable autumn it appears that there were fewer weevils in the fields at that time than in the preceeding year. Fewer were noticed in the gin trash at ginning time and while it was possible to locate fields with a moderately high weevil population, this condition was the exception rather than the rule.

COMPARATIVE WEEVIL POPULATION IN EASTERN OKLAHOMA IN FALL OF 1934.—In the fall of 1934 a small portable gin trash inspection machine was utilized in scouting for the pink bollworm. This machine was invented by R. E. McDonald of the U. S. Department of Agriculture. While examining the gin trash for pink bollworms, the boll weevils recovered were counted. Although only a small percentage of those present in the fields was brought in with the gin trash this proportion remained fairly constant and gave a picture of the comparative boll weevil population in different parts of eastern Oklahoma. The survey was made from October 10 to 27 inclusive in 16 counties in which 58 gins were visited. From one to seven samples of trash were inspected per county. The results showed that the weevils were most abundant in the southeastern section whereas elsewhere the infestation varied from very light to moderate.

TABLE 1. AVERAGE NUMBER OF BOLL WEEVILS PER ACRE AND AVERAGE PERCENTAGE OF SQUARE INFESTATION, OKLAHOMA 1931–1934 INCLUSIVE

Date	Average number of weevils per acre				Average percentage of square infestation			
	1931	1932	1933	1934	1931	1932	1933	1934
May 22–25	—	—	—	320	—	—	—	—
May 29–June 1	—	—	—	262.5	—	—	—	—
June 5–9	96.6	128	72	198.9	—	—	—	—
June 11–16	188	352	50	259.2	—	—	7.6	36.9
June 18–21	203.3	374	40	344.4	—	48.5	7.4	31.3
June 21–30	106.6	—	40	507.5	23.5	42.2	10.2	36.6
								26.5
July 3–8	—	—	—	—	16.3	37.95	5.9	19.3
July 9–13	—	—	—	—	14.98	41.2	5.5	16.8
July 14–22	—	—	—	—	13.8	51.6	6.6	18.8
July 20–26	—	—	—	—	22.2	57.2	13.1	29.6
July 27–Aug. 3	—	—	—	—	27.2	76.7	28.3	26
								40.2
Aug. 11	—	—	—	—	56.2	90.4	56.0	—
Aug. 17	—	—	—	—	70.6	—	81.0	—
Aug. 25	—	—	—	—	90.4	—	91.3	—

TABLE 2. AVERAGE PERCENTAGE OF GREEN BOLL INFESTATION, COMPARATIVE PERCENTAGES OF WEEVILS IN DIFFERENT STAGES FOUND IN INFESTED BOLLS AND AVERAGE NUMBER OF WEEVILS PER ACRE, MCCURTAIN CO., OKLAHOMA, 1934

Date	Average percentage of green boll infestation	Percentage of weevils in bolls as Larvae	Pupae	Adults	Emerged	Total number of stages found	Average number of weevils per acre
Aug. 11...	24	91.8	6.6	1.6	0	60	250*
Aug. 17–18.	22.3	83.2	13.7	3.1	0	95	—
Aug. 23–24.	25	63.4	18.3	16.1	2.2	93	508.3
Aug. 29–31.	21.7	63.9	16.8	19.3	0	83	625
Sept. 6–7..	24	67.6	7.8	20.7	3.9	102	1100
Sept. 12–13	—	—	—	—	—	—	1075

*Aug. 15.

CONCLUSIONS.—In 1934 a severe drought effectively checked an early boll weevil infestation so that practically no damage was done to cotton by this pest. Due to extremely high temperatures the weevil was almost exterminated in fallen squares. It was able to survive, however, in fairly large numbers in cotton bolls which were not affected by the heat. The broods of weevils emerging from bolls in the late summer produced a large supplementary fall generation in late squares which were developed in unusually large numbers by the plants due to heavy rains in September and November. Because of late frosts this large supplementary brood went into hibernation in good condition.

SCREW WORMS IN THE SOUTHEASTERN STATES

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About 70 years ago, and again approximately 35 years ago, screw worms were reported in Pearl River County and surrounding counties in Mississippi. At different times since these first reports, persons residing in this section observed a few cases in livestock, but the number of infestations did not reach the proportions of an epizootic. In October of 1932 infestations were common in this section but most of them were mild in nature. In the autumn of 1933 and again in 1934 the infestations were abundant and caused many losses of livestock.

In Georgia the first case of screw worms was reported by Dr. H. B. Raffensperger from the vicinity of Boston in July 1933. By September of that year cases were present in the southern counties and in two separate areas of northern Florida. Screw worms appeared near the boundary line of the two States before any livestock were imported from the drought-stricken areas of the western States. During 1934 screw worms increased rapidly in the Southeastern States, and since the invader was new the stockmen were not prepared to cope with it. Where there were only a few pens and chutes for the handling of animals, the fly became firmly established and multiplied in such numbers as to precipitate the most destructive outbreak ever recorded for the pest.

LIFE CYCLE OF THE SCREW WORM, *Cochliomyia americana*.—Screw worm flies deposit eggs in masses of 30 to 100 upon moist locations in wounds of animals. Within about 10 to 12 hours the young screw

worms hatch from the eggs and feed in clusters so as to produce cavities in the wounds. Within 5 to 7 days most of the screw worms become fully developed and drop to the soil for pupation. They burrow beneath the surface of the soil and usually pupate within a few hours. During the summer months the pupal period lasts about 7 to 10 days but it is greatly extended during low temperatures. The minimum period from deposition of eggs to emergence of adult flies was found to be about 12 days. Usually the period requires 14 or 15 days. After flies emerge from the pupal stage, mating occurs on about the third day and eggs are laid at any time after the fifth or sixth day. As a rule about 3 weeks is required for the complete life cycle.

DIAGNOSIS.—Screw worms crowd into pockets of wounds, leaving only their posterior ends exposed. As they feed on living tissues and body fluids of the wounds, they rupture small blood vessels and cause bleeding. A wound infested with screw worms has a characteristic discharge containing blood and usually it is accompanied by a hard swelling. (Fig. 111.) The odor of an infested wound is extremely offensive and nauseating, and is more or less characteristic of such infestations. Usually the larvae found in such wounds are the immature stages of the fly belonging to the species *Cochliomyia americana* Cushing and Patton.[1] This species is the primary invader of wounds and is considered the true screw worm of North America.

Infestations of screw worms are sometimes mixed with infestations of ordinary maggots of blowflies. When the wounds represent extensive areas of decaying tissues, *Cochliomyia macellaria* Fab., which breeds in carcasses during the summer months, is apt to infest the animal.

During the winter months *Cochliomyia americana* is not very active in areas experiencing killing frosts. Some infestations occur during warm periods of winter lasting for two weeks or more. At such times the black blowfly, *Phormia regina* Meig., which develops in carcasses, occasionally lays eggs on old wounds or on the soiled wool of sheep. The larvae of this species feed normally on dead animals and are not nearly so destructive to live animal tissue as *Cochliomyia americana*.

EFFECT OF ATTACK.—An untreated infestation of screw worms usually results in the death of the infested animal, either on account of continued infestation or from resulting complications. The animal may live for a week or more but it becomes weak and emaciated and strays from the herd. Just how long the animal lives depends entirely upon the location of the infestation and the abundance of maggots in the wound. Untreated wounds usually harbor screw worms of different sizes and ages, and as the screw worms develop the wound increases in size. If the infestation is located in the muscular portions of the body it may persist for several weeks. If it is located in the navel of a young animal it may quickly result in peritonitis and death. An infestation following dehorning or an infestation occurring in the nasal passages may produce meningitis and cause the death of the animal.

[1]Cushing, Emory C., and Patton, W. S. 1933. Studies on the Higher Diptera of Medical and Veterinary Importance. *Cochliomyia americana* sp. nov., the Screw-Worm Fly of the New World. Annals Trop. Med. and Parasit. 27:539–551, 7 figs. 3 refs.

Although animals may recover from severe infestations of screw worms, the loss of weight, vitality, and resistance caused by the attack renders them more susceptible to other parasites and diseases and leaves them in poor condition to withstand the hardships of winter.

FIG. 111.—A characteristic screw worm infestation following branding of a yearling.

EXTENT OF INFESTATION.—In the Southeastern States where cattle, sheep, and hogs are allowed freedom of unfenced areas, the screw worm

FIG. 112.—A screw worm infestation which resulted in loss of an eye. The discharge from the eye caused flies to start another infestation beneath the eye. See also figures 113 and 114.

became a very serious pest. In Georgia the first infestation during the season of 1934 was reported from Hinesville on May 15. Shortly after

this time screw worms became abundant and were destructive until after a killing frost in November. In addition to a rapid and gradual spread of the invader, new foci of infestation appeared well in advance of the infested zone. It is estimated that nearly one-half million cases occurred in the State of Georgia and that about one and one-half million cases occurred in the Southeastern States. These records are based on observations and questionnaires received from agricultural agents.

During the control campaign against screw worms conducted in Mississippi in 1934, reports were obtained from farmers and stockmen as to the number of animals owned and the actual number and kinds of animals infested with screw worms. A compilation of 8,078 of these reports obtained from 21 counties shows that of 128,057 cattle reported, 14,253 or 11 per cent were infested; of 11,605 goats reported, 811 or nearly 7 per cent were infested; of 6,530 dogs, 933 or 14 per cent were infested; of 13,609 horses and mules, 1,291 or 9 per cent were infested, and of 94,173 hogs, 11,807 or 12 per cent were infested. These figures show that an average of approximately 11.4 per cent of all animals were infested with screw worms.

The highest incidence of screw worms in cattle and hogs in Mississippi was recorded from Marion County. Of 1,953 hogs reported, 460 or 23.5 per cent were infested; of 5,705 cattle reported, 1,795 or 31.4 per cent were infested. The highest incidence for sheep was reported from Hancock County. Of 10,306 reported, 4,051 or 39.3 per cent were infested. The high incidences were reported from unfenced grazing lands along rivers and small tributaries where the Gulf Coast tick was abundant on different kinds of animals. In such locations the lands actually flooded by water were largely free from ticks, but the lands bordering the swamps seemed to be well infested with them. Reports on the percentage of infestation in Georgia and Florida compare closely with those obtained in Mississippi.

Predisposing Causes.—Any scratch, cut or abrasion caused by dog bite, tick bite, ear mark, castration, or other external injury on warm-blooded animals is suitable for screw worm flies to deposit their eggs. (Fig. 112.) In different localities and during different seasons of the year one can trace screw worm cases to definite types of injury and to definite practices. (1) For example, in 1934 the majority of the early cases of screw worms occurred in navels of newly born calves and pigs. If the sires had been under control and the breeding properly timed, the young animals would have been born before the screw worm flies became active. (2) A second group of screw worm cases was definitely attributed to late surgical operations. Native cattle were castrated and ear marked during May, June, and later. Such operations could have been performed during the winter or before the flies became active. (3) A third group of injuries occurred on open range areas where the Gulf Coast tick, *Amblyomma maculatum* Koch, was numerous on different kinds of animals. By July 15, ticks were plentiful on sheep, hogs, and cattle, and the screw worm flies were numerous enough to cause many infestations in the injuries made by tick bites. Screw worm cases due to such injuries were observed so frequently that there was a general tendency

of stockmen to attribute all screw worms to injuries produced by the bites of ticks. They were not inclined to consider other conditions which contributed to the larger population of screw worm flies. (4) By the time the group of injuries resulting from tick bites had contributed to the production of screw worms, the flies were sufficiently numerous to find and infest most of the wounds of animals on farms. During this period such cases appeared in the penis sheath of mules and horses and in other places where screw worms are rarely found. Because some of these locations were so unusual, many persons having only a few animals in fenced pastures were led to believe that all their animals would become infested, and they would lose most of their livestock.

From the four general classifications of infestations it is seen that three of them result principally from open range practices and that the trouble in the fourth group is intensified by the presence of flies bred up in wounds caused by the three other types of injuries.

MORTALITY.—Questionnaires were sent to the county agents of the infested area in Georgia, and 24 replies give a summary of the status of the incidence of screw worm cases and mortality of animals on September 15. The average total number of cases in each of 24 counties was 1,178; the average number of cases on September 15 was 474; the average number of cases cured or dying before September 15 was 704, and the average number of deaths before September 15 was 137, or a mortality of 19.4 per cent.

The rate of mortality is a significant figure, in that it shows that either the animals were not treated or that they were improperly treated. There is no reason to believe that any animal should die of screw worms if the cases are recognized early and treatments are made promptly according to the recommendations of the Bureau of Entomology and Plant Quarantine. Because of lack of information on the subject, and in desperation, stockmen had begun using harmful materials, such as coal tar, roof paint, creosotes, strong stock dips, and carbolic acid for the treatment of open wounds. Peddler remedies consisting of such materials were responsible for many of the deaths of animals. It was evident that the greatest need was for an educational program. The stockmen needed to know what to use and how to use it, as well as what not to use and why he should not use certain materials.

TREATMENT.—For the treatment of screw worms, the Bureau of Entomology and Plant Quarantine recommends benzol and pine-tar oil. Benzol is used to kill the screw worms and pine-tar oil is used as a dressing for the wound and for repelling the flies. Before these materials are applied the portions of the animal covered with discharges from the wounds are carefully cleaned. The wound is then made as dry as possible by swabbing it with cotton, care being taken at the same time to avoid additional injury to the tender tissues. Following the swabbing of the wound, an application of benzol (commercial 90 per cent) retards the flow of body fluids and assists in drying the wound. A cotton plug is then moistened with benzol and inserted in the opening of the wound. (Fig. 113.) The plug is allowed to remain in place long enough to make certain that the fumes of the benzol have had sufficient time to kill

the worms. More than one application of benzol is frequently necessary to insure the killing of all the larvae. While the removal of the dead maggots from the wound is desirable, investigations have shown that such a procedure as carried out by stockmen usually results in fresh bleeding and injury of the tissues, which thus increases the danger of reinfestation. A benzol-soaked cotton plug should be left in the wound to make absolutely certain that all the maggots are killed. Both the cotton plug and most of the dead larvae will drop out of the wound in

FIG. 113.—Wounds are cleaned and are then treated with benzol. Cotton plugs moistened with benzol and left in the wounds so that screw worms can breathe the fumes.

a day or so. Pine-tar oil (specific gravity 1.065 to 1.085, acid-free, dehydrated) is applied over the cotton plug and around the wound. The pine-tar oil repels flies and aids healing. (Fig. 114.) It is necessary to apply pine-tar oil every day or two until the wound heals. Following the first treatment, the reappearance of a bloody discharge from the wound suggests that living larvae are present. In such cases treatment with benzol should be repeated. If there is no further discharge from the wound, the condition suggests that there are no living screw worms in the wound and that only the pine-tar oil should be applied. Cotton wrapped about a clean stick is useful in spreading the pine-tar oil on the animal.

In treating animals for screw worms, phenols, creosotes, coal tars, or roof paints should not be used. These often result in phenol poison-

ing, which may either kill the animal or cause swellings and stiffness of the joints. Wounds treated with such materials often appear as though they had been cooked. Experience has shown that any material strong enough to kill screw worms quickly by coming in contact with them is also injurious to the tissues of the animal. It is seldom necessary to do surgical operations on infested wounds. They should not be cut open with a knife, nor should the ears or tails of animals infested with screw worms be cut off unless a screened house is available in which to keep

FIG. 114.—Pine tar oil is applied on the cotton plugs and about the wounds to repel flies and to aid healing.

the animal until the injury is healed. Do not probe the wounds with sticks or rusty wires or cause any bleeding of the wound. Treat the wounds carefully with benzol and pine-tar oil and they will heal promptly.

EDUCATIONAL WORK.—In the autumn of 1933, at the request of county agents and stock owners of the infested counties of Georgia, the senior author, together with Dr. H. B. Raffensperger, of the Bureau of Animal Industry, Dr. William E. White, of the Georgia Department of Agriculture, and F. M. Prince of the Bureau of Entomology and Plant Quarantine held meetings in more than 30 counties.

During the summer of 1934 about 40 meetings were held by W. E. Dove and R. A. Roberts of the Bureau of Entomology and Plant Quarantine, in cooperation with M. S. Yeomans, State Entomologist of Georgia, Dr. William E. White, and Dr. H. B. Raffensperger. These meetings were followed by a program conducted under the direction of

Mr. R. L. Vansant, Rehabilitation Division, Georgia Emergency Relief Administration. The serious depredations of the screw worms made it necessary to enlarge this work. Through arrangements with the Federal Emergency Relief Administration at Washington and in different States of the Southeast, an educational program was conducted in each State. In Georgia, where so many counties were infested, it was necessary to assign a man to a group of from 6 to 15 counties. During a period of 8 weeks 18 men held 842 meetings and demonstrations, with a total attendance of 26,583 persons. This number did not include the larger key meetings held at the beginning of the program. The work was in cooperation with the Extension Service and other agencies interested in the welfare of livestock in Georgia.

During the week of November 8, 1934, replies were received from questionnaires sent to 50 counties in Georgia. The average number of cases in 50 counties on November 8 was 2,852; the average number of deaths in 50 counties on November 8 was 351, and the mortality of infested animals was 12.4 per cent. It is seen that the death rate of 19.4 per cent on September 15 was reduced to 12.4 per cent on November 8. This substantial reduction in mortality was brought about during the period when the number of cases increased from an average of 1,178 per county to an average of 2,852 per county. The reductions were greater in counties where educational work was done.

In Mississippi an intensive program for the control of screw worms was carried on during the fall of 1934 under the direction of one of the authors (Parman), and the number of cases of screw worms was reduced approximately 50 per cent during a period of 3 weeks. This reduction is attributed to prompt and thorough treatment of infested animals. The work in Mississippi, Georgia, and Florida demonstrates the necessity of doing educational work for screw worm control in a very intensive manner.

THE SCREW WORM OUTBREAK IN FLORIDA

By W. V. KING and G. H. BRADLEY, *Bureau of Entomology and Plant Quarantine, United States Department of Agriculture*

The first screw worm cases in Florida were reported from the extreme northern part of the State in the spring or early summer of 1933, and before the end of the season infestations had occurred in some 18 or 20 counties. The fly continued to spread rapidly during 1934 and by the end of that year 31 of the 67 counties in the State had a general infestation, 15 were partially or moderately infested, 11 had reported scattered cases, and 10 were without reported cases.

The counties which had a general infestation are all in the northern half of the State, while those with only scattered cases or without reported infestation are in the central and southern portions. A part of those classified as moderately infested border on the heavily infested northern counties and the others comprise a small group in the southwestern part of the State.

As might be expected, the sudden appearance of so serious a pest, resulting almost immediately in a considerable loss of livestock, caused much alarm among the stock owners, who were unfamiliar with the habits of the insect and totally unprepared to cope with it. Information furnished by the Bureau of Entomology and Plant Quarantine on the subject was disseminated as rapidly as possible by that Bureau in cooperation with the County Agricultural Agents, the staffs of the State Extension Service and the State Live Stock Sanitary Board. In September 1934 a State-wide educational program was arranged under the supervision of the United States Department of Agriculture, in cooperation with these State agencies and with the Florida Emergency Relief Administration. A fund of $7,500, made available through the Commodity Division of the Relief Administration, provided for the appointment of 28 county supervisors, and the organization thus established covered a total of 51 counties. In the majority of these, educational meetings were held, demonstrations of case treatment were given, and pamphlets of instruction were distributed. As a means of acquainting the stock owners with the materials recommended for use in the treatment of screw worm cases, approximately 800 gallons each of benzol and pine-tar oil were issued free in quantities of one pint or less.

The educational program was continued for about seven weeks. During this time, as estimated, more than 17,000 stock owners were reached through meetings or by individual contact and several thousand screw worm cases were treated in demonstrating the use of benzol for killing the larvae and of pine-tar oil as a fly repellent.

SURVEY OF INFESTATIONS DURING 1934.—In a survey of the screw worm infestations occurring in the State during 1934, records of the number of cases and deaths were accumulated by the county supervisors from information furnished by individual stock owners. A total of 3,404 such reports were obtained from 45 counties and these have been summarized in Table 1, under two groups of counties, to show the number of animals reported on and the proportion of cases and deaths.

TABLE 1. SURVEY OF SCREW WORM INFESTATIONS IN TWO GROUPS OF COUNTIES IN FLORIDA DURING 1934

Classes of animals	Number of animals	Total reported Cases	Deaths	Percentage Cases	Deaths
Group 1—Thirty-one counties with a general infestation					
Cattle	149,185	20,402	2,036	13.68	1.36
Horses and mules	5,536	483	19	8.72	.34
Hogs	108,164	33,720	12,874	31.17	11.90 (9.43)*
Sheep	36,948	2,782	2,388	7.53	6.46
Goats	7,240	1,812	956	25.03	13.20
Totals	307,073	59,199	18,273	19.28	5.95 (5.87)*
Group 2—Fourteen† counties with a partial or moderate infestation					
Cattle	93,344	998	138	1.07	.15
Horses and mules	1,882	32	1	1.70	.05
Hogs	10,792	364	81	3.37	.75
Sheep	6,882	19	1	.28	.01
Goats	857	7	6	.82	.70
Totals	113,757	1,420	227	1.25	.20

*The percentages given in parenthesis were obtained from a weighted average of the losses for hogs in 23 counties from which 50 or more reports each were available. Similar averages for other classes of animals did not change the figures materially and are not, therefore, shown.

†No reports available for one other country in this group.

On a part of the reports as obtained, "cases treated" were listed and animals which died were not included with these; therefore we have estimated, for a final index of infestation, that at least half of the deaths should be added to the number of cases shown. For the counties in group 1, this would give an infestation rate in hogs of 36 to 37 per cent and for all classes of animals of about 22 per cent.

As a very rough estimate of the total deaths in the State from screw worm injury, the percentages given in Table 1 may be applied to the available census figures for the same two groups of counties, with the results as shown in Table 2.

TABLE 2. CENSUS TOTAL OF ANIMALS, AND THE INDICATED DEATHS FROM SCREW WORM ATTACK IN TWO GROUPS OF COUNTIES

	Census total		Indicated deaths*		
	Group 1	Group 2	Group 1	Group 2	Total
Cattle	364,612	192,522	4,959	289	5,248
Horses and mules	44,699	8,953	152	4	156
Hogs	474,393	63,450	44,735†	476	45,211
Sheep	30,985	11,872	2,002	1	2,003
Goats	27,816	2,981	3,672	21	3,693
Total	942,505	279,778	55,520	791	56,311

*Based on percentages obtained in survey.
†Using the percentage of 9.43 as the rate for hogs. (See footnote, Table 1.)

The census figures for animals other than cattle were taken from the Census Bureau publications for 1930; those for cattle[1] were obtained from a census compiled in 1930–31 in connection with the cattle tick eradication work and are regarded as being more nearly complete than the Census Bureau records, the total number being about twice as great.

The number of reports received and the proportion of the different classes of animals represented varied for the different counties. A weighted average of the losses per county did not, however, materially change the figures except in the case of the death rate in hogs, which is shown in Table 1 and used as the percentage for indicated deaths in Table 2. If the original percentage of 11.9 is employed, the total loss of hogs becomes approximately 57,000 and of all animals, 68,000.

In regard to the records as obtained, it is likely that the tendency would be to secure a larger proportion of reports from owners having the most trouble and also, on the part of the owners themselves, to overestimate the cases and losses. On the other hand, many cases were treated by FERA workers, and a good many deaths must have occurred in range animals, without the owners' knowledge. Furthermore, the census figures, except possibly those for cattle, are probably too low. On the whole, it is our impression that an estimated loss of more than 50,000 animals, including new-born animals, is conservative. The monetary loss for these might be placed tentatively at $250,000, with an equal amount to cover the expense of treating cases and the injury to animals that recovered.

It may be noted from the preceding tables that by far the largest number of cases and the greatest losses have occurred in hogs. At present,

[1]Cattle brought into the state by the Federal Government from drouth areas are not included in the data given here.

the area of general infestation is also the principal hog-producing section of the State, as is shown by the following comparison of the average number of cattle and hogs per county in three groups of counties:

Extent of Infestation		Cattle	Hogs
General	(31 counties)	11,761	15,303
Partial or moderate	(15 counties)	13,093	4,245
Only scattered cases	(11 counties)	11,769	1,314

Numerous screw worm cases in hogs would of course tend to maintain a large fly population and to result in larger numbers of cases in other kinds of animals. The possible advantage that the central and southern sections of the State have in this respect at the present time, however, may be offset in the future to some extent, owing to the fact that a greater proportion of the cattle in most of these counties are kept on large open ranges, where they are less subject to control measures.

Origin of Screw Worm Cases.—Screw worm cases are found to develop in almost any kind of abrasion or wound that presents a point of entrance for the young larvae; and the necessary operations of marking or branding, castrating, et cetera, as well as accidental injuries, are frequent sources of infestation. Under certain conditions, as in newborn animals, cases occur in the eyes and other natural openings, apparently without previous abrasion of the skin or mucous membranes. Estimates of the relative frequency of attack in different types of wounds were requested from the field workers in an effort to obtain more specific information on this subject for the Florida cases. The average of the percentages given in 21 replies are shown in Table 3.

Table 3. Estimates of the Proportion of Screw Worm Cases Originating in Different Types of Wounds

Origin of infestation	Cattle	Hogs	Horses and mules	Sheep	Goats
		Average of estimated percentages			
Marking	10.3	18.0	—	5.3	5.9
Branding	5.3	—	—	—	—
Castration	12.0	32.1	1.0	4.7	12.9
Dehorning	8.1	—	—	—	—
Sores caused by ear ticks	24.8	9.8	4.2	53.1	33.9
New-born animals*	24.4	13.5	—	6.6	10.8
Accidental injuries	8.4	17.9	48.4	12.8	19.7
Other causes	6.6	8.7	46.4†	17.5	16.8

*Principally navel infestations.
†Principally in penis sheath.

The preceding figures indicate that sores caused by tick bites are an important source of screw worm cases. The estimates of such cases for certain areas ran as high as 85 per cent for cattle, 60 per cent for hogs, 95 per cent for goats, and 100 per cent for sheep. Several species of ticks may be involved in these ear cases, although the Gulf Coast tick, *Amblyomma maculatum*, is believed to be the principal one. The blacklegged, or castor bean tick, *Ixodes ricinus* var. *scapularis*, is also more or less prevalent in the State and may be responsible for a certain proportion of such cases.

County Relief Administration Projects.—Local screw worm projects were in operation for from one to six months in 26 or 27 of the more heavily infested counties. Most of these projects provided riders

or laborers to assist the stock owners in the handling and treatment of range animals and in disposal of carcasses. Fly-trapping campaigns were carried out in some of the counties and labor was also furnished for the building of pens and hospital pastures. The amount expended under these projects during 1934 was slightly less than $100,000. Totals were reported of approximately 66,000 case treatments, 11,000 carcasses destroyed, 2,100 traps operated, and 122 pens constructed.

CERTAIN PHASES OF THE CONTROL PROBLEM.—Since the screw worm fly appears to be permanently established in the State, measures for meeting the immediate problem have been under consideration by the cooperating agencies. With our present information, attention must be directed primarily to the prevention of screw worm attack, which, in addition to the actual treatment of wounds, involves important problems of herd management. Some of the measures recommended in this connection for other areas, which are also applicable to Florida conditions, include the building of an adequate number of pens, chutes, and hospital pastures for the convenient handling and treatment of infested or injured animals; developing better pasturage and restricting the ranging of animals to enable more frequent inspection of all stock; eliminating, so far as possible, the causes of accidental injuries; treating ear tick infestations; and, especially, taking adequate precautions with the animals after operations and after the birth of young.

The number of infestations is greatly reduced by performing the operations of marking, castrating and dehorning in the winter months, and by controlling the breeding season so that the young are born late in the winter and early in the spring, a practice that coincides with good herd management as well as with the less active period of the screw worm fly. The use of the pincer type of emasculator has also proven an effective means of avoiding infestations in castration wounds.

In Florida, however, it appears that the fly may continue to be somewhat active in the winter months. During January 1935 an unexpectedly large number of new cases were reported from widely scattered points, two of which were within a few miles of the Florida-Georgia boundary line. Specimens obtained from eighteen of these cases have all proved to be the true screw worm, *Cochliomyia americana* C. & P., with the exception of one lot containing larvae of the black blowfly, *Phormia regina* Meig. These infestations developed following an exceptionally severe freeze in December, during which minimum temperatures of 19 to 21 degrees occurred well south of the center of the State. The indication, therefore, is that there may be no period of the year when precautionary measures against the screw worm will not be required. As much of the range stock in Florida overwinters solely on poor natural forage and is more or less unfit for rearing young at this time of year, the practice of bringing the calf crop in winter is not without its difficulties.

Owners of dairy and other animals which are well cared for and subject to frequent inspection have been able to meet the situation for the most part without serious loss. The most difficult problems to be met are those connected with the hog-producing and range-stock industries, and it appears certain that some of the range practices will have to be

considerably improved in order to cope effectively with screw worm infestations. As most of these changes are in line with improved herd-management practices advocated by leading animal husbandmen, their adoption should lead to a more profitable livestock industry in the State. Before a program applicable specifically to Florida conditions can be fully worked out, however, further study and research are needed on the bionomics of the fly and on local problems of herd management. The study must develop, among other things, methods of utilizing large range areas which are capable of supporting only very limited numbers of animals and hardly of sufficient grazing value under present conditions to warrant fencing into pastures small enough to permit convenient inspection and handling of the animals.

THE SCREW WORM SITUATION IN ALABAMA

By J. M. ROBINSON, *Entomologist, Alabama Agricultural Experiment Station, Auburn, Alabama*

The screw worm (*Cochliomyia americana* C. & P.), known to feed upon living tissues of warm-blooded animals, was reported as affecting domestic animals in Southeast Alabama during the summer of 1933 and was very active over a considerable part of the state in 1934. In early June of 1934 the screw worm was discovered infesting livestock in Bullock, Henry, Russell, and Mobile Counties. All of these counties are located in the southern third of the State. During this same time, some thirty odd thousand of drouth relief cattle had been shipped into Alabama from the mid-west and had been distributed in Montgomery and adjacent counties. When the relief cattle became infested the Alabama Relief Administration officials immediately appealed to and received the assistance of the State Veterinarian. In Washington County, also in the southern third of the state, the infestation affected so many farm animals that by early August the county officials appealed for assistance. Therefore, when the call for assistance was presented to the A. R. A. by the Washington County officials, such aid was granted and the State Veterinarian was authorized to make plans for the eradication of this pest which was seriously affecting the health of the domestic and wild animals of that County.

During August the appeals for assistance in controlling the screw worm in South Alabama came to the attention of the Extension Specialists of the Department of Animal Husbandry and to the Entomologist of the Agricultural Experiment Station. In response to these requests information was obtained from the Bureau of Entomology and other reliable sources, which was used in the preparation of recommendations for the control of this pest. Such recommendations were distributed to the county agents, teachers of vocational agriculture, and other interested parties. Information concerning the habits and control of the screw worm was released to the press from time to time. In addition to the distribution of printed literature, the Extension Specialists gave

demonstrations of treatment for infested wounds in living animals and methods of burning carcasses.

In some counties the relief workers were used in locating infested cattle, in demonstrating treatments, and in destroying dead animals.

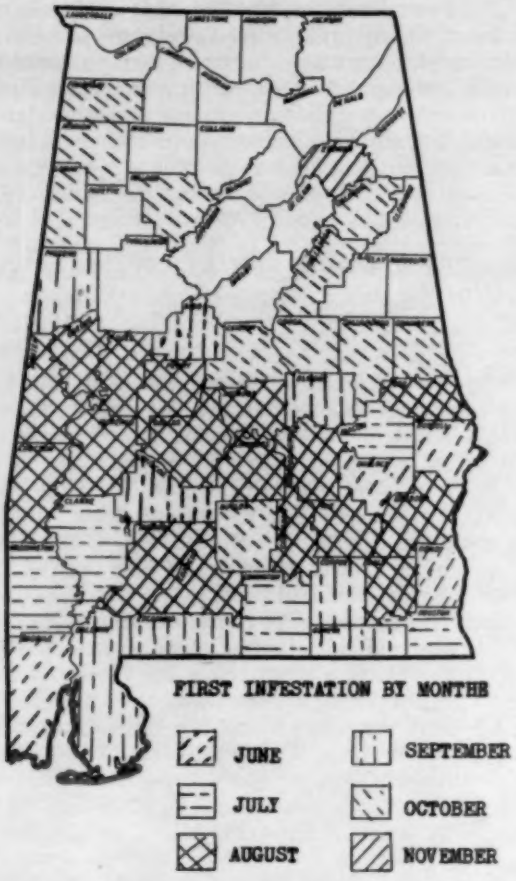

FIG. 115.—Screw worm distribution in Alabama, 1934.

An example of this method of control was taken from a weekly report ending October 18, 1934. "Twelve men worked 66 days, they traveled 859 miles, visited 598 farms, and gave 206 demonstrations. They reported 202 cattle infested, 161 treated, 16 burned, and 3 buried. The same men during this period found 30 infested mules, treated 17, burned 1, and buried none. They also found 153 other animals infested, treated 102, burned 5, and buried 5."

As the appeal for further assistance advanced northward in the state throughout the summer it was deemed advisable to obtain a clearer view of the distribution of this pest as well as to gain some idea of the kinds and number of animals affected. A comprehensive questionnaire was prepared by the staffs of the Entomology and Animal Husbandry Departments. This questionnaire was sent to the county agents and teachers of vocational agriculture. The data obtained was summarized. Table 1.

ANATOMICAL DISTRIBUTION OF THE INFESTATIONS.—Answers to that portion of the questionnaire "What parts of the animal were infested" revealed that "any part of the body where sufficient abrasion for as much as a drop of blood to collect was sufficient for the beginning of a screw worm infestation." Among the thirty different parts of the body reported as infested, the nose, ears, sides of the body, umbilicus, and vagina were most frequently mentioned.

GEOGRAPHIC DISTRIBUTION OF THE SCREW WORM.—As reported by county agents and teachers of vocational agriculture the first appearance of the screw worm in Alabama by counties was rather spotted throughout the year. The earliest appearance, which was the first of June, was in four widely scattered counties definitely in the southern third of the state (Distribution map). By the latter part of July the infestation had advanced northward into Macon County, making a total of nine counties reporting infested animals. During August infested animals were reported from seventeen additional counties, all of which were in the southern half of the state. The infestation continued to spread northward during September, October, and November. During the season warm-blooded animals in approximately three-fourths of the state had been affected by the insect. In November a mule was found infested in Etowah County, which is in the northern third of the state. After the sub-freezing weather, which occurred over the state on November 13, no further infestations were reported.

TABLE 1. SCREW WORM INFESTATION IN ANIMALS, THE NUMBER TREATED, AND THE TOTAL DEATHS REPORTED BY COUNTY AGENTS AND TEACHERS OF VOCATIONAL AGRICULTURE IN ALABAMA IN 1934

Animals	Number animals reported					
	Infested		Treated		Died	
	Co. Agt.	Tea. Voc. Ag.	Co. Agt.	Tea. Voc. Ag.	Co. Agt.	Tea. Voc. Ag.
Mature cattle	13,764	1,645	11,071	1,487	876	52
Yearlings	8,586	510	7,400	477	717	33
Calves	7,190	845	6,345	824	425	41
Sheep	5,625	17	3,443	7	2,585	5
Hogs	5,681	1,231	4,341	1,075	592	119
Mules	1,083	279	993	270	11	6
Horses	728	77	638	77	55	0
Dogs	899	50	778	44	22	6
Cats	100	5	57	5	15	3
Chickens	160	39	60	38	60	17
Humans	15	11	15	8	1	4
Deer	20	1	0	1	5	0
Others	300	14	75	10	20	1
Total	44,151	4,724	35,216	4,323	5,384	287
Per cent			80	91	12	6

MOSQUITO COLLECTIONS IN FLORIDA WITH THE NEW JERSEY LIGHT TRAP

By G. H. BRADLEY and T. E. MCNEEL, *Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture*

The mosquito trap developed by T. J. Headlee (2) and his associates for determining the mosquito fauna of a given locality, and used in New Jersey for the past two or three years, was given a test at Orlando, Florida, during the summer and fall of 1932. The single trap which was used was of the revolving type bearing a wind vane.

COMPARISON OF HAND AND TRAP COLLECTIONS IN FLORIDA.—The writers' experience in operating one of these traps near Orlando, Fla., indicates that, although there is no question of its usefulness in sampling the mosquito fauna, it has not always given results comparable to hand collecting when a hand collector and the trap operate at the same location over the same period of time. However, when the trap was allowed to run all night, usually a greater variety of mosquitoes was taken than was taken by hand, and most of the species taken by hand were represented in the trap collection. On 19 nights during the season (July 6 to November 10, 1932) hand collections were made over the same periods of time and at the same locations that a trap was operated. In making the hand collections two persons usually were present, one acting as "bait" and the other doing the collecting, those mosquitoes alighting on the collector being brushed off and not collected. The number of collecting periods in one night ranged from one to nine. For comparative purposes the records obtained from the hand collections for each night have been averaged on the basis of one 15-minute collection by one person, and the trap records have been averaged on the basis of one 15-minute collection per night. These data are presented in Table 1. Only female mosquitoes taken in the trap were included in this comparison, as males are rarely taken by hand.

It is seen that an average of three less mosquitoes were taken in the trap than were taken by hand, and that there was considerable variation between the average number of specimens of each species or group taken by the two methods. The trap showed the presence of larger numbers of those species that are less active biters than those predominating in the hand collections. The commonest mosquitoes in the locality in which the tests were made are undoubtedly *Mansonia perturbans* and *Anopheles crucians* as demonstrated by the trap collections. As to actual annoyance, however, the hand collections represent the more accurate index, and they did not show any abundance of *A. crucians*. The trap collections also indicated more of the two groups of Culex and of *Uranotaenia* spp. than were taken by hand, and fewer *Aedes* spp. and *Psorophora columbiae*.

COMPARISON OF 15-MINUTE AND ALL-NIGHT COLLECTIONS.—On the 19 nights in which the data summarized in Table 1 were obtained, the trap was operated all night. Table 2 gives the results of these all-night collections, expressed in percentages of the total mosquito col-

TABLE 1. NUMBER OF FEMALE MOSQUITOES COLLECTED BY HAND AND IN TRAPS DURING AN AVERAGE 15-MINUTE PERIOD ON 19 NIGHTS BETWEEN JULY 6 AND NOVEMBER 10, 1932

Method	All species	Anopheles *quadrimaculatus* Say	Anopheles *crucians* Wied.	Anopheles *walkeri* Theo.	Culex Mochlostyrax[1]	Culex Culex[2]	*Mansonia perturbans* Walk.	*Psorophora colombiae* D. & K.	*Aedes* spp.	*Uranotaenia* spp.
Hand.....	16.62	0.01	0.08	0.21	0.06	0.67	14.49	0.59	0.48	0.03
Trap.....	13.17	.09	2.40	.49	.87	1.05	5.57	.05	.03	2.62

[1]Subgenus Mochlostyrax; chiefly *C. inhibitor* D. & K.
[2]Subgenus Culex; chiefly *C. salinarius* Coq., *C. nigripalpus* Theo., *C. quinquefasciatus* Say.

TABLE 2. PERCENTAGES OF FEMALE MOSQUITOES OBTAINED IN 15-MINUTE HAND AND TRAP COLLECTIONS AND IN ALL-NIGHT TRAP COLLECTIONS, ON 19 NIGHTS BETWEEN JULY 6 AND NOVEMBER 10, 1932

Method	Period	All species Number	Anopheles *quadrimaculatus* Per cent	Anopheles *crucians* Per cent	Anopheles *walkeri* Per cent	Mochlostyrax[1] Per cent	Culex[2] Per cent	*Mansonia perturbans* Per cent	*Psorophora columbiae* Per cent	*Aedes* spp. Per cent
Hand....	15-minute	16.59	0.03	0.49	1.28	0.40	4.01	87.34	3.57	2.88
Trap.....	15-minute	10.56	.91	22.73	4.64	8.26	9.94	52.77	.50	.25
Trap.....	All night	265.84	.61	49.57	8.26	9.00	6.06	24.65	1.17	.67

[1]Subgenus Mochlostyrax; chiefly *C. inhibitor*.
[2]Subgenus Culex; chiefly *C. salinarius, C. nigripalpus, C. quinquefasciatus*.

TABLE 3. PERCENTAGES OF FEMALE MOSQUITOES COLLECTED EACH HOUR DURING THE NIGHT

Month	Species	Total number	Percentage of mosquitoes taken during hour indicated: 8 to 9 p.m.	9 to 10 p.m.	10 to 11 p.m.	11 to 12 p.m.	12 to 1 a.m.	1 to 2 a.m.	2 to 3 a.m.	3 to 4 a.m.	4 to 5 a.m.
July[1].....	All.....	1,739	15.35	14.72	17.60	10.64	11.21	8.57	7.76	7.88	6.27
	Mansonia perturbans	577	27.21	23.29	12.65	8.15	8.32	7.11	4.85	4.16	4.16
	Anopheles crucians	241	11.20	10.37	14.52	16.18	17.43	7.47	7.05	10.37	5.39
August[2]...	All	4,010	14.29	11.22	12.97	12.54	10.20	12.47	9.13	10.67	6.51
	Mansonia perturbans	483	28.78	17.39	10.56	10.35	5.16	8.49	4.76	9.11	5.38
	Anopheles crucians	2,083	8.99	9.62	15.10	15.91	11.25	13.17	8.89	11.59	5.62

Month	Species	Total number	Percentage of mosquitoes taken during hour indicated: 7.30 to 8.30 p.m.	8.30 to 9.30 p.m.	9.30 to 10.30 p.m.	10.30 to 11.30 p.m.	11.30 to 12.30	12.30 to 1.30	1.30 to 2.30 a.m.	2.30 to 3.30 a.m.	3.30 to 4.30 a.m.	4.30 to 5.30 a.m.
September[2]	All	3,934	8.39	11.21	14.74	14.59	11.90	11.54	7.37	9.56	6.89	3.81
	Mansonia perturbans	284	14.08	13.72	9.86	11.62	12.68	8.45	4.58	11.27	7.04	6.69
	Anopheles crucians	2,889	7.48	10.59	14.99	15.09	11.66	11.60	8.24	9.55	6.89	3.91

[1]Two collections during the month.
[2]Four collections during the month.

lection, together with the percentages of the total in the 15-minute hand and trap collections. The collections of *Uranotaenia* spp. have been omitted, as they are unimportant from the standpoint of either annoyance or disease carriage. The all-night collections show larger percentages of Anopheles mosquitoes (except *quadrimaculatus*) than either the 15-minute trap collections or the hand collections. *Mansonia perturbans*, on the other hand, although present in large numbers in the all-night collections, was much less abundant than in the 15-minute collections by the trap or by hand. This difference is probably due to the fact that Anopheles mosquitoes show marked activity throughout the greater part of the night, whereas Mansonia are most active early in the night, at which time the 15-minute collections were made. Of the less abundant species, *Culex* spp. were present in trap collections in larger numbers and *Aedes* spp. and *Psorophora columbiae* in smaller numbers than in the hand collections.

TIME OF GREATEST ACTIVITY OF MOSQUITOES.—As a result of his studies on light trapping of mosquitoes in New Jersey, Doctor Headlee concluded that there are only three hours during the night when the mosquitoes are really active. To determine if this was also true under Florida conditions, during July, August, and September trap collections were made hourly throughout each night on 10 nights near Zellwood, Fla. The data obtained on *Mansonia perturbans* and *Anopheles crucians*, the two most common mosquitoes of importance in the locality, are given in Table 3. These data indicate considerable activity at all hours of the night, but that in all three months Mansonia mosquitoes were most active during the early part of the night whereas Anopheles showed greatest activity in the middle of the night.

RELATION BETWEEN TEMPERATURE AND MOSQUITO ACTIVITY.—Temperature readings made hourly during 8 of the 10 nights ranged from 66° to 81°F. The total numbers of mosquitoes taken during hours when each degree of temperature within this range prevailed (Table 4) indicate that temperatures of 70° or above are favorable for mosquito flight in this locality, but that below 70° flight is very much inhibited.

TABLE 4. HOURLY TRAP COLLECTIONS OF MOSQUITOES IN RELATION TO TEMPERATURE

Temperature °F.	Collections number	Mosquitoes collected Average number	Range number
66–67	6	36.5	10–59
68–69	7	71.7	30–145
70–71	2	155.0	54–256
72–73	26	220.9	18–610
74–75	17	194.3	14–451
76–77	14	208.6	63–555
78–79	2	175.0	108–242
80–81	2	180.0	135–225

SEASONAL ABUNDANCE AS DETERMINED FROM TRAP COLLECTIONS.—The results of 28 all-night trap collections made from July to November, during which period a total of 24,489 mosquitoes were taken, are given in Table 5. These collections were all made at the same location near Zellwood, Fla. The collection records are arranged by months, and the average of the lowest temperatures on the nights on which collections were made is given for each month. It is shown that the highest aver-

age collection occurred in July when the minimum temperature averaged the highest. Each succeeding month showed a lower average collection and a lower average minimum temperature. The greatest number of mosquitoes taken in a single collection was 3,628, on the night of September 2–3, when the minimum temperature was 73°F. The records given in Table 5 indicate that as long as the minimum temperature was approximately 70°F. or above there was considerable mosquito activity and that below that point activity was greatly reduced.

Table 5 also shows the total numbers of mosquitoes caught each month and the numbers of the various species or groups comprising these totals. Of chief interest here is the behavior of *Anopheles crucians* and *Mansonia perturbans*. The abundance of *M. perturbans* followed the trend of the total mosquito population with regard to average minimum temperature and season. The abundance of *A. crucians* increased from July to September, during which period there was a slight decline in the average minimum temperature, and then followed the general trend in showing a sharp falling-off in numbers on the cool nights of October and November.

It was observed that nights which were rainy or on which strong winds occurred were not favorable for large mosquito catches. A bright moon over any considerable period also appeared to be unfavorable, the trap accumulating the largest numbers on still, dark nights.

COMPARISON OF TRAP RECORDS WITH RECORDS OF LARVAL COLLECTIONS.—No general collections of mosquito larvae for the season are available for comparison with these trap records. A few records of Anopheles larvae, however, were made in close proximity to where the trap was operated. Although these showed *crucians* to be the predominating anopheline, they showed a much higher relative abundance of *A. quadrimaculatus* larvae as compared with *A. crucians* larvae than is shown by the trap records of adults of these species. These larval collections, however, may not be representative of the entire breeding area from which the trap collection was drawn. These larval collections indicate that the trap is not so efficient in collecting *A. quadrimaculatus* as it is in collecting *A. crucians*. In this connection it may be stated that Headlee (2) reported taking only one *A. quadrimaculatus* during the entire season in New Jersey, during which time he was operating several traps in different sections of that State.

COMPARISON OF TRAP RECORDS WITH FINDINGS BY OTHER METHODS.—The abundance of *Mansonia perturbans*, as gauged by trap collections, coincided quite closely with the findings of McNeel (3), whose observations over three seasons showed that there are two peaks of abundance of this pest during the year at Zellwood, Fla., the first one occurring early in May and the second during the first few days of August. The records here given show July to be the heaviest Mansonia month, but the individual collection records show that this was due to the fact that the largest single collection of this species was made in this month on the night of July 28–29. The trap records, therefore, indicated the peak of abundance of this species and this peak occurred close to the same general period as had been ascertained for it by abundance records made by other methods during previous years.

TABLE 5. SEASONAL RECORD OF ALL-NIGHT TRAP COLLECTIONS OF MOSQUITOES NEAR ZELLWOOD, FLA., JULY TO NOVEMBER, 1932, INCLUSIVE

Species or group	July (3 collections)		August (4 collections)		September (5 collections)		October (12 collections)		November (4 collections)	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Total	3,010	3,228	3,272	4,116	3,681	4,782	967	1,148	62	223
Average per night, all mosquitoes	1,003.3	1,076.0	818.0	1,029.0	736.2	956.4	80.6	95.7	15.5	55.7
Anopheles:										
quadrimaculatus	.67	18.33	.75	4.00	0	8.40	.08	.58	0	0
crucians	99.33	206.60	271.50	528.50	436.60	694.00	25.08	39.58	5.25	19.00
walkeri	0	12.67	0	91.50	0	40.80	0.08	5.00	0	1.25
Culex:										
Mochlostyrax[1]	94.00	87.67	35.75	60.25	21.00	30.80	9.58	9.58	1.50	3.75
Culex[2]	7.33	22.00	16.25	23.50	9.40	10.60	2.08	1.42	2.25	17.00
Mansonia:										
perturbans	16.67	242.60	17.00	124.25	13.20	64.00	0.25	4.25	0	0
Psorophora:										
columbiae	0	3.00	0	1.75	0	2.40	0	0	0	0.25
Aedes spp[3]	.67	1.00	0	.50	0	0	0.75	.17	0	0.50
Uranotaenia spp[4]	784.33	482.00	476.75	194.50	256.00	105.40	42.58	35.08	6.50	14.00
Average minimum temperature, °F.	74.0		72.3		69.6		62.7		58.8	

[1]Chiefly *C. inhibitor.*
[2]Chiefly *C. salinarius, C. nigripalpus, C. quinquefasciatus.*
[3]*A. taeniorhynchus* Wied., *A. infirmatus* D. & K., *A. sollicitans* Walk.
[4]*U. sapphirina* O. S., *U. lowii* Theo.

RELATIVE ABUNDANCE OF MALES AND FEMALES.—The relative abundance of males of *Anopheles crucians* as compared with that of females during the season is of interest. Boyd (1), in studying the number of generations of *A. quadrimaculatus*, has found that periods when males are most predominant coincide with the times of emergence of new generations. Table 6 gives the percentage of males in weekly catches of *Mansonia perturbans* and *Anopheles crucians* in Florida. These records for *A. crucians* show that peak percentages of males appear in the collections at approximately monthly intervals (July 21, August 18, September 15). This may indicate new broods of *A. crucians*, but it is rather peculiar that on each of these dates the total numbers of this species entering the trap were much lower than they were in the preceding or succeeding weekly catches.

TABLE 6. COLLECTIONS OF MANSONIA PERTURBANS AND ANOPHELES CRUCIANS, SHOWING PERCENTAGES OF MALES IN FLORIDA, JULY TO NOVEMBER 1932

Date 1932	Mansonia perturbans		Anopheles crucians	
	Total number	Males per cent	Total number	Males per cent
July 8	162	11.1	554	31.6
15	[1]128	5.5	[1]59	32.2
21	137	9.5	70	55.7
28	469	3.8	294	28.6
August 4	113	6.2	204	17.2
11	248	9.9	750	40.0
18	132	21.2	176	50.0
25	72	5.6	2,070	32.4
September 2	84	22.6	2,482	27.7
8	140	16.4	1,003	55.3
15	51	13.7	151	62.9
22	64	9.4	770	23.2
29	47	23.4	1,247	53.4
October 6	0	0	6	50.0
13–14	[2]22	13.6	[2]79	50.6
19–21	[3]22	0	[3]224	38.4
26–27	[2]3	0	[2]200	36.5

[1]Only partial night's catch.
[2]Total catch for two successive nights.
[3]Total catch for three successive nights.

In the collections of *Mansonia perturbans* a much smaller male population as compared with the female population is indicated. No definite trends throughout the season are shown, except for the absence of males late in the season, when, however, only small total numbers were taken. During the period of greatest abundance of this species, which has been taken as an indication of the time of emergence of a fall brood in this locality, instead of an increase in the percentage of males, there is a marked decrease, as was the case with *A. crucians*.

SUMMARY.—A light trap for mosquitoes developed by T. J. Headlee in New Jersey was found to be an efficient collector of mosquitoes for determining the status of these insects in Florida.

An all-night trap collection was found to be a more valuable index of the relative abundance of mosquito species than short collections.

Hourly trap collections indicated a considerable mosquito activity throughout the night. *Mansonia perturbans* was most active early in the night, whereas *Anopheles crucians* was most active during the middle of the night.

Temperatures of 70°F. or above were most favorable for mosquito activity.

The seasonal abundance of *Mansonia perturbans* and of *Anopheles crucians* is discussed and the results obtained by the trap collections are compared with those obtained by other methods. The relative abundance of males and females as found by trap collections is discussed.

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PEST MOSQUITO CONTROL IN ALABAMA UNDER C. W. A.

By F. E. GUYTON, *Associate Professor of Zoology-Entomology, Alabama Polytechnic Institute, Auburn, Alabama*

The use of 819 men in Mobile and Baldwin Counties for the control of pest mosquitoes by drainage was authorized by Dr. F. C. Bishopp of the Federal Bureau of Entomology early in December 1933. The Alabama Directors[1] of the project began work on the fifth of December and two weeks from that date the full quota of 800 laborers was employed. The work continued as Federal project F-26 until February 15 and from that date until March 29 it was State project S-227.

The principal equipment consisted of nearly 700 pairs of rubber boots and a like number of shovels. Other equipment consisted of axes, picks, water buckets, dippers, scythes, etc. Several hundred pounds of dynamite and a ten-inch triple block and tackle with one-inch rope were used in the State project. No machinery of any type was used.

The principal pest mosquito of the above counties is *Aedes sollicitans* Walk. Its breeding habitat is in marshes having a salinity of 10 to 15 per cent. Ten other species of mosquitoes were collected on the various areas of the Alabama project and identified by G. H. Bradley of the U. S. Bureau of Entomology as *Culiseta inornata* Will., *Culex salinarius* Coq., *Anopheles crucians* Wied., *Aedes taeniorhynchus* Wied., *Aedes vexans* Meigen., *Psorophora columbiae* D. & K., *Mansonia perturbans* Walk., *Aedes atlanticus* D. & K., *Psorophora ferox* Hum., and *Culex quinquefasciatus* Say.

LOCATION OF PROJECT.—The main part of the project was located south of Mobile on the Cedar Point Road where Dog River empties into Mobile Bay. Both sides of the road at this point were bordered with salt marshes and were found to be, even at this time of the year, full of mosquito larvae and pupae. The marshes continue north of Cedar Point Road both on the east and west side of Dog River to a point near the City of Mobile. Since the salt marsh mosquito, *Aedes sollicitans*, commonly travels 15–20 miles, the entire Dog River marsh presented a

[1]B. P. Livingston, State Director. F. E. Guyton, Asst. State Director.

mosquito menace to the citizens of Mobile, which is the center of population of Mobile County. Therefore, the supervisory staff decided that this territory was the most important one in the County and the first ditching was begun on this area.

Other places ditched in Mobile County were the Arlington Dock and the Three Mile Creek areas in the city limits of Mobile, and the Bayou LaBatre area. In Baldwin County two areas were ditched, one at Gulf Shores and the other along the Bon Secour River.

FIG. 116.—Sloped ditch used in clay areas underlaid with sand; also a paspalum spike grass association.

TYPES OF MARSHES.—The marsh types varied in the different areas. The Dog River marsh consisted largely of peaty material, although some areas were mucky. One area consisted of a semi-floating or trembling bog. Thirty-five acres of this marsh consisted of small areas some of which were composed of peat and others of sandy clay.

The Bayou LeBatre marshes consisted largely of peat. One area (Fig. 116), requiring nearly 10,000 linear feet of ditching, consisted of a top of 18 inches of clay under-laid with sand. This area also had what might be called a meadow marsh—a high firm marsh composed of clay and peat heavily loaded with sand. The water when present in this meadow received its salinity by abnormally high wind-driven tides. Rain furnished the water for mosquito breeding on this type of marsh.

The Three Mile Creek area in the city limits of Mobile presented the worst conditions under which to work. Besides being very boggy, almost the entire area was covered with a heavy growth of trees (Fig. 117). These trees proved to be of minor importance in ditching this area

in comparison to the many well preserved fat pine stumps present which were completely covered by the marsh. One 3000-foot ditch contained 67 stumps.

The Arlington Dock area was a typical salt marsh and although small in area it was capable of producing enormous numbers of *A. sollicitans*.

The major area in Baldwin County, bordering Bon Secour River, as a whole was a firmer marsh than any of the others mentioned. This condition facilitated ditching operations.

FIG. 117.—Wooded marsh of the Three Mile Creek area; also 3000-foot main ditch which contained 67 "blind" stumps.

DRAINAGE PROBLEMS.—Salt marsh ditching for mosquito control had never been practiced in Alabama. Therefore, many problems on which there was no data had to be worked out by the so-called trial and error method. Some of the important problems encountered are illustrated by the following questions: How wide should the ditches be? Would 10-inch ditches, as recommended by Headlee, Bulletin 348, page 61, New Jersey Agricultural Experiment Station, be sufficiently wide for the laterals in Alabama marshes? Should the laterals be 100, 150, or 200 feet apart? Should the sides of the ditches be sloping or straight? How deep should the ditches be? What type of marshes should be ditched? Where and how should the dirt from the ditches be piled? What type of tools would be needed, etc.? It was found by experiment that no set rule could be formulated that would solve the above problems but that each problem varied according to the type of marsh encountered.

DITCH CONSTRUCTION AND DIMENSIONS.—The width of the lateral ditches varied from a 15-inch top and bottom to a 3-foot top and a 1-

foot bottom. The 15-inch ditch was not satisfactory in soft peat or muck marshes but it did fairly well in solid peat bogs. Due to bog variations, however, the 20-inch lateral was finally adopted for all peat and muck marshes. The distance between laterals varied with the marsh type from 100 to 200 feet. Although 100 and 125-foot distances were used more than any others, it is believed that a large part of the peaty marshes would give perfect drainage with the laterals spaced 150 feet apart. This spacing would be too great for the clay marsh types where the drainage was more imperfect.

It was found advisable to use ditches with sloped sides for the sandy clay or meadow type of marsh. Ditches with twenty-four-inch tops and fifteen-inch bottoms held up well, provided pure sand was not encountered at the bottom of the ditch. When, in order to get the proper depth, it was necessary to cut through the clay into the underlying sand, a ditch with a three-foot top and a one-foot bottom was used.

Main ditches varied in width from two feet to six feet, depending upon the length of the ditch and the type of the marsh. The depth of the ditches varied from twelve to twenty-four inches at their source to low tide level, which was usually twenty-four inches. Parallel main ditches in series were placed 600 feet apart. These were to have been connected with staggered laterals 200 feet apart.

The dirt from the ditches was placed in heaps alternately on each side of the ditch three or four feet from the edge of the bank. This was done in order that the water would have a free course from the marsh to the ditch. Dirt placed along the edge of the bank in a continuous heap has a tendency to block the water from the ditch by compacting the underlying material.

Relation of Vegetation to Larval Population.—A definite relation existed between the type of vegetation and the number of larvae found in an area. Larvae were usually found in areas covered with paspalum, and the areas where larvae were most numerous were practically always covered with paspalum or a mixture of paspalum and spike grass. Wooded marshes ranked next to paspalum as a breeding ground and was followed in order by pure stands of spike and saw grass.

Organization and Operation of Labor Forces.—The supervisory and labor forces were organized as follows:

State Director
Assistant State Director

Engineers	5
Entomologists	3
County Supervisors	2
Project Supervisors	2
Chief Timekeeper	1
Timekeepers	6
Chief Foremen	5
Foremen	30
Laborers	758

This organization of the personnel worked very satisfactorily. The entomologists first surveyed the marshes making a map showing where mosquito larvae and/or pupae were found and also showing the type

of vegetation of the marsh. After the entomologists mapped the area they made a report to the assistant state director, who, in conference with the entomologists, engineers, and sometimes technical advisors furnished by the Federal Government, decided which areas should be drained. The engineers then made the survey, staking the ditches every hundred feet with laths on which the depth of the ditch at that point was marked. The engineers then prepared maps of the area. These maps served as guides to the county and project supervisors, and foremen.

PARTIAL STATISTICAL SUMMARY.—The following figures present a partial statistical summary of the Federal and State projects:

*Total linear feet ditched		749918
Linear feet ditched per day		15788
Linear feet ditched per day per man		28.7
Cubic feet displaced	2519527	
Area ditched (acres)	2109	
Area ditched per day (acres)	44.4	
Linear feet ditched per acre	355	
Number working days	47.5	
Average number men per day	550	
Cost of ditching per linear foot		$0.12
Cost of ditching per cubic foot		$0.036
Cost of ditching per acre		$43.55
Cost of ditching per day		$1,933.92
Cost of entire projects		$91,861.30

*All figures based on ditches 20 inches wide.

EFFECTIVENESS OF CONTROL MEASURES.—In order to ascertain the effectiveness of the ditching operation, two inspections were made during the summer of 1934. On May 8 and 9, G. H. Bradley of the Federal Bureau of Entomology, Technical Advisor of the project, inspected all projects in Mobile County. Concerning the major project in the Dog River area he states: "The ditches in this area, which was the principal Alabama project, are in good condition and no larvae or adult mosquitoes were noted in the places visited. The soil was becoming very firm on the surface and being largely of a peaty nature it drains exceedingly well. The ditches were swarming with fish. No trouble is expected from this area."

In July of the same year the writer made an inspection of all the drained areas. The ditches were in good condition and were draining the connected areas perfectly. The large ditches in the Three Mile Creek area were partially filled with pickle weed. This did not interfere to any appreciable extent with the flow of the tide in the ditches. All ditches inspected were abundantly supplied with top minnows. The general public was very favorably impressed with the results of the ditching. A high percentage of the people interviewed in the drained area claimed quite a reduction in the mosquito population of their communities.

RECENT EXPERIMENTS IN THE CONTROL OF THE PECAN NUT CASE BEARER IN THE SOUTHEAST

By G. F. MOZNETTE, *Entomologist, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture*

The control of the pecan nut case bearer, *Acrobasis caryae* Grote, has presented a problem for solution under the climatic conditions existing in the Southeast. The results of experimental work carried out in the past indicate that this insect can not be effectively controlled with arsenical sprays, such as lead arsenate, at strengths which do not cause injury to the foliage of the pecan in that area.

A study of this insect in the Southeast has shown that most of the damage to pecan nuts is caused by the first generation during May and early in June, the peak of greatest destruction occurring during the last two weeks of May. The damage by the succeeding generations is not very extensive, possibly owing to the fact that the parasites greatly reduce the numbers of the first-generation larvae when they are in the small nuts. However, the larvae of the first generation are able to cause a great deal of destruction before the parasites have checked their activity. Hence it was thought that one or at most two applications of some contact spray against the eggs and newly hatched larvae, made during the last two weeks in May, might protect the set of nuts during the period of year when the greatest destruction normally occurs.

CONTROL EXPERIMENTS IN 1932 AND 1933.—Commencing with the season of 1932, experiments were initiated to determine to what extent the insect could be controlled by the following sprays: Nicotine sulfate with summer-oil emulsion, nicotine sulfate with fish oil, summer-oil emulsion, pyrethrum extract, and derris extract. During 1933 experiments were continued with similar sprays. Some of the plats received one application of the above sprays, early in the period of egg deposition, and others received an additional application eight to ten days later. Although the infestation of nut clusters by the pecan nut case bearer during 1932 and 1933 was rather light in the orchards where the experiments were conducted, the extensive counts made in all plats during both seasons indicated significant differences in control.

Effective control was obtained with summer-oil emulsion with nicotine, and also with fish oil in combination with nicotine. Summer-oil emulsion used alone was much less effective. Sprays containing pyrethrum and derris extracts produced very unsatisfactory results. There appeared to be little difference in control between one and two applications of the nicotine-oil spray. No outward sign was observed of foliage injury.

CONTROL EXPERIMENTS IN 1934.—Experiments with contact sprays were continued during 1934 in a pecan orchard at Monticello, Fla. The orchard is one that has good cultural care in the way of fertilization, cover crops, and cultivation. The Moore variety of pecan which has proved to be consistent in producing a set of nuts, was used in the experiments. The major troubles in the way of insects and diseases at-

tacking this variety are the pecan nut case bearer and foliage diseases. During the first week of June an excessive "June drop" occurred in all trees throughout the experimental orchard. Such an excessive drop is usually attributed to inadequate pollination, and occurs in varying degrees nearly every year. In 1934 it caused as great a loss as the nut case bearer.

Two oil emulsions of the "summer-oil" type were used in the experiments of 1934. These and the fish oil used were analyzed by the Insecticide Division. Oil emulsion No. 1, used in Plats 1 and 2, contained 80.1 per cent total oil by weight and the extracted oil had a viscosity of 63 seconds (Saybolt) and an unsulfonated residue of 92.8. Oil emulsion No. 2 contained 84.2 per cent total oil by weight and the extracted oil had a viscosity of 61 seconds (Saybolt) and an unsulfonated residue of 96.8 per cent. The analysis of the fish oil showed it to have a specific gravity of 0.929, free fatty acid calculated as oleic acid 8.3, iodine value (Hanus Method) 145, and saponification value 195.

At the cessation of the feeding activity of the larvae of the first generation, counts were made of the infested and noninfested clusters. All clusters on the trees were examined for a distance of 20 feet above the ground. The trees averaged 45 feet in height. Yield and grading records were also taken at harvest time.

A study of Table 1 shows that the nicotine-oil combination was effective in the control of the pecan nut case bearer. Two applications of summer-oil emulsion No. 1 in combination with nicotine sulfate in Plat 1 gave a control of 97.0 per cent. In Plat 2, which received two applications of oil-emulsion No. 1, on the other hand, there was a control of only 42.8 per cent. A single application of summer-oil emulsion No. 2 in combination with nicotine sulfate in Plat 3 gave a control of 93.0 per cent, only a little less than that secured in Plat 1 where two applications of a similar spray were made. Two applications of a nicotine-fish oil combination as applied in Plat 4 gave a control of 98.7 per cent. Plat 6, which received a nicotine-Bordeaux combination spray in the first application and nicotine-oil in the second, gave a control of 95.3 per cent. The purpose of using Bordeaux mixture in the first application was to control foliage diseases. Throughout the season the foliage on the trees in Plat 6 was in much better condition as far as freedom from foliage diseases was concerned than the foliage on the check trees. However, the summer oil-emulsion used in plats 1 to 3 apparently imparted some benefit in checking foliage diseases throughout the season.

The check Plats, 5 and 7, showed an average infestation of 24.1 per cent of the nut clusters and the average yield for these two plats, as shown in Table 1, was about half as great as the yield secured in Plats 1, 3, or 6 and also considerably less than that secured in Plats 2 and 4.

Grading records showed that in Plat 1, receiving two applications of oil-nicotine, there was a slightly smaller proportion of nuts in the higher sizes (13/16 inch and 14/16 inch) than in Plats 3 and 6, receiving only one application of the oil-nicotine. This reduction in size may have been caused by the application of the additional spray. The nuts on Plats 3 and 6 in turn were slightly smaller than those on the unsprayed

TABLE 1. SUMMARY OF RESULTS SECURED IN SPRAYING EXPERIMENTS IN THE CONTROL OF THE PECAN NUT CASE BEARER, MONTICELLO, FLA., 1934

Plat No.	Number of trees	Treatment	Date of application	Date clusters examined	Total number of clusters	Infested clusters		Control	Yield of nuts
						Number	*Per cent*	*Per cent*	*Pounds per tree*
1	7	(1) Summer oil-emulsion No. 1, ¾–100 Nicotine sulfate (40 per cent nicotine) 1–1,000	May 18 May 25	June 1	2,998	22	.7	97.0	44.3
		(2) (same)	May 18 May 25	June 4	2,586	357	13.8	42.8	36.8
2	7	(1) Summer oil-emulsion No. 1, ¾–100 (2) (same)							
3	7	(1) Summer oil-emulsion No. 2, ¾–100 Nicotine sulfate (40 per cent nicotine) 1–1,000	May 18	June 4	3,011	51	1.7	93.0	46.7
4	7	(1) Fish Oil ¼–100 Nicotine sulfate (40 per cent nicotine) 1–1,000	May 18 May 25	June 5 June 4	2,611 2,410	8 565	.3 23.4	98.7 ——	38.0 26.8
		(2) (same)							
5	7	Check No. 1							
6	7	(1) Bordeaux mixture 2–2½–50 Nicotine sulfate (40 per cent nicotine) 1–1,000	May 18						
		(2) Summer oil-emulsion No. 1, ¾–100 Nicotine sulfate (40 per cent nicotine) 1–1,000	May 25	June 5 June 5	3,582 3,187	41 785	1.1 24.6	95.3 ——	47.6 19.5
7	10	Check No. 2							

trees in Plats 5 and 7. In this case, however, the thinning of the crop in the unsprayed trees by the nut casebearer may have been responsible for the difference.

Further experiments are necessary to determine if one application of a nicotine-fish oil or a nicotine-Bordeaux combination spray will give a control comparable to that secured with one application of the nicotine-oil combination.

CONTROL OF THE PECAN WEEVIL

By H. S. SWINGLE, *Associate Entomologist, Alabama Agricultural Experiment Station, Auburn, Alabama*

The pecan weevil (*Curculio caryae* Horn) is the most important insect pest of pecans in central and northern Alabama and one of the most important throughout the northern range of the pecan belt. In groves in central Alabama this insect has caused an average loss over a six-year period of approximately forty per cent of the Schley crop.

Pecan nuts are damaged by these insects in two ways. First, the feeding of the male and female weevils upon the immature nuts during the month of August causes the nuts to sour and to fall to the ground. This damage is often very severe and occasionally over eighty per cent of the entire crop of Schleys has been lost in this manner. Second, each female requires from ten to thirty or more nuts in which to deposit her eggs, and where large numbers of weevils are present, practically the entire harvested crop may be wormy.

The pecan weevil will feed and lay eggs in most of the common varieties of pecans, but damage is usually most severe upon Schleys and Stuarts and control measures are usually necessary only upon these varieties. When Schley and Stuart nuts are not available in sufficient amounts for feeding and oviposition, enough damage may be done to Success and Van Demans to warrant the use of control measures.

Various methods of control have been tried, but the only one which has proved of value is the removal of the adult weevils from the trees by jarring. In Central Alabama the adult weevils begin to emerge from the soil the first of August and weevils continue to emerge until the second week in September. The peak of emergence is reached during the period of August 21–27. Egg deposition does not begin until the pecan kernels have begun to harden, which occurs during this same period. Large numbers of weevils are present therefore upon the trees from one to two or more weeks before egg-laying begins, and many can be removed by jarring before they are able to reproduce.

Preliminary experiments for the control of the pecan weevil by jarring were begun in 1930 at Camp Hill, Alabama, and since 1931 have been conducted at both Camp Hill and Lanett, Alabama, whenever sufficient crops of nuts were available. From emergence records it was determined that jarring should be started about the middle of August. Jarring was repeated at weekly intervals until the end of the first week in September.

METHODS USED IN JARRING.—Picking sheets were placed under the spread of the trees and each large limb was sharply jarred two or three times, either from the ground by the use of a padded pole, or in the case of higher trees by climbing the tree and jarring each large limb with the foot. When the limbs were extremely large they were jarred by using a padded club. Light jarring was sufficient to dislodge the weevils, whereas heavy jarring was very undesirable as this caused many sound nuts to fall. The weevils were then removed from the sheets, counted, and killed by dropping into kerosene. Trees having a limb spread up to sixty feet were successfully jarred by this method.

It was found that jarring could be conducted successfully throughout the day, although the weevils remained quiet upon the sheets for a much longer time in the morning and evening than they did during the middle of the day. Jarring was much less successful during a high wind because the weevils were much harder to dislodge and many were blown beyond the sheets while falling.

RESULTS AND DISCUSSION.—The results of these experiments are given in Table 1. The control secured varied from 60.0 to 85.8 per cent, with an average of 69.5 per cent. The per cent of control obtained on Schleys was less than on Stuarts due partly to the smallness of the crops of Schleys during these years, and partly to the preference of the weevils for this variety. It is very doubtful, however, if much more than a seventy per cent control can ordinarily be secured by jarring, as those weevils emerging during or after the period August 20–27 can lay a considerable number of eggs before they are jarred from the trees.

COST OF JARRING.—The time required to jar a tree depended upon the size of the tree, the height of the limbs from the ground, and the number of weevils picked up from the sheets. It was found that a crew of five men, using two sheets, jarred from fifteen to thirty trees per hour, where the trees had a limb spread of fifty to sixty feet and the limbs were close to the ground. For trees having the same limb spread, but with the limbs headed high so that it was necessary to climb the trees, the same sized crew jarred only from five to eight trees per hour.

TABLE 1. RESULTS OF JARRING EXPERIMENTS FOR THE CONTROL OF THE PECAN WEEVIL

Year	Location of experiment	Variety of pecan	Treatment	Number trees sampled	Number nuts examined	Per cent injury by weevil	Difference in per cent injury	Per cent control
1933	Lanett, Ala.	Schley	Jarred trees	5	5642	13.1 ±0.7	19.6 ±3.9	60.0
			Checks	3	3860	32.7 ±3.8	———	——
1934	Lanett, Ala.	Schley	Jarred trees	6	799	19.3 ±3.1	44.7 ±4.3	69.9
			Checks	3	3088	64.0 ±3.1	———	——
1934	Camp Hill, Ala.	Schley	Jarred trees	8	2242	19.2 ±3.0	31.5 ±3.3	62.1
			Checks	3	5230	50.7 ±1.4	———	——
1934	Lanett, Ala.	Stuart	Jarred trees	10	4103	3.9 ±0.8	23.5 ±0.8	85.8
			Checks	3	8416	27.5 ±0.2	———	——

Figuring the cost of farm labor at ten cents per hour, the cost of jarring the low spreading trees was approximately three cents per tree and for high top-worked trees it varied from six to ten cents. Since the trees were jarred three to four times, the total cost per season per tree was nine to twelve cents for low spreading trees, and from eighteen to forty cents for high top-worked trees. A saving of from one to four pounds of nuts per tree will pay for the labor of jarring.

CONCLUSIONS.—Injury by the pecan weevil can be greatly reduced by jarring. This has been found to be an economical method of control. In central Alabama jarring should begin on approximately August 15 and should be repeated at weekly intervals until the first or second week in September.

CONTROL OF THE BEAN WEEVIL AND THE COWPEA WEEVIL

By S. MARCOVITCH, *Tennessee Agricultural Experiment Station*

In 1917 Metcalf[1] found that cowpeas could be protected from the ravages of the weevil, *Mylabris quadrimaculatus*, by mixing the peas with one or two parts of lime. Because of the low cost of lime and the fire hazard connected with the use of carbon disulphide, the lime treatment has been recommended in various texts and applied also to the bean weevil, *Mylabris obtectus*, a closely related species of the same genus working on beans. Such an assumption, however, proved to be misleading, for further investigation proved that the two species have a variety of habits, many of which are not common to both.

In bulletin 150 (1934) of the Tennessee Experiment Station the author showed that beans could be protected by mixing them with lime at the rate of one part of lime to fifty parts of beans. Since Metcalf recommended a two-to-one treatment, or about 25 times as much lime, an explanation was sought to reconcile the differences. The thoroughness with which the beans were mixed with the lime seemed to be of great importance, and this explanation appeared satisfactory at the time. The series of tests conducted with beans all showed that when mixed with 2 per cent of lime, they were free from infestation.

However, when the same tests were conducted with cowpeas, 2 per cent of lime did not give protection. In fact, protection was not obtained until 50 per cent lime was used, as recommended by Metcalf. The discrepancy now seemed clear. It was due to two different species of insects being employed and that wide differences in their habits must account for the explanation.

HABITS OF THE TWO SPECIES.—Casual examination of infested beans and cowpeas reveals that both species have similar habits, yet a study of their ways showed wide differences in many respects. In the first place *M. quadrimaculatus* confines itself to cowpeas, whereas *M. obtectus* to beans. Cowpea weevils when placed on beans, will cover them with their large white conspicuous eggs. Upon hatching, the small larva will make an attempt to enter but soon dies. Beans do not seem to be suitable food for the cowpea weevil. In the same way, *M. obtectus* was found to be incapable of breeding in cowpeas.

One does not have to work very long with both species to discover that the *M. quadrimaculatus* is very much more active and alert than *M. obtectus*. Perhaps for this reason adult cowpea weevils were found

[1]Metcalf, Z. P. Lime as an Insecticide. Jour. Econ. Ent. 10:74. 1917.

to be more resistant to lime. In individual tests on the effect of lime on the adults at the end of 96 hours, 100 per cent of bean weevils had succumbed, while only 50 per cent of the cowpea weevils were dead in the same time.

As is well known, the bean weevil lays its eggs loosely among the beans. The cowpea weevil, on the other hand, glues her large white eggs in a conspicuous manner over the surface of the peas. The larvae upon hatching enter the seed just beneath the point where the egg is deposited. Such a method of entrance protects the very small larvae against any possible injury of dusts. It is very likely that larvae of the bean weevil crawl around prior to entrance, thus coming in contact with any dusts that may be used for protection. In other words, the lime treatment in case of the bean weevil works not only against the adults, but on the newly hatched larvae, and for this reason less lime is needed to obtain control.

RESULTS OF DUST PROTECTION.—The methods employed in testing the effects of dusts against the cowpea weevil were the same as those reported for the bean weevil in bulletin 150 of the Tennessee Agricultural Experiment Station. As in the case of hydrated lime, the cowpea weevil was found to be more resistant to sodium fluosilicate. The former required a concentration of one part of sodium fluosilicate to 500 parts of seed for protection, while the bean weevil only one part in 1000 was sufficient.

SUMMARY.—The cowpea weevil, *Mylabris quadrimaculatus*, was observed to attack only cowpeas (*Vigna sinensis*), while the bean weevil, *M. obtectus*, confines itself to beans (*Phaseolus* sp.). The cowpea weevil proved much more resistant to the effect of dusts. Fifty per cent hydrated lime mixed with the cowpeas gave protection, while only 2 per cent lime was necessary to protect beans against the bean weevil.

With sodium fluosilicate one part to 500 parts of cowpeas gave protection, while one part to 1000 parts of beans was sufficient.

CALCIUM ARSENATE AS A CONTROL MEASURE FOR THE TOBACCO FLEA BEETLE AND HORNWORM

By W. W. STANLEY and S. MARCOVITCH, *Tennessee Agricultural Experiment Station*

For many years lead arsenate was accepted as the standard insecticide for the control of the tobacco hornworm, and Paris green for the flea beetle. More recent work (Marcovitch, 1931, and Chamberlin, 1933) has shown that barium fluosilicate (Dutox) gives better control of flea beetle than Paris green, with less danger of foliage injury. Also, due to the agitation in the last few years against poisonous spray residues as health hazards, the use of lead compounds is now discriminated against for control of hornworm. With a view to finding a satisfactory substitute for lead arsenate on tobacco, tests were carried out, in 1933 and 1934, with lead arsenate, calcium arsenate, Paris green, fluorine compounds, derris, and pyrethrum.

EXPERIMENTAL METHODS USED.—Experiments were carried out, under field conditions, on approximately one acre of tobacco that was divided into a number of small areas, or sub-plots. Each sub-plot was of known size, about 60 feet long and 9 to 12 rows wide. Poison dusts were applied on three sub-plots, with three replications for each material. The amount of dust used per acre was found by weighing the duster before and after each application.

In 1933, data on the degree of control were obtained by counting, on the third day after poisoning, the number of live worms and beetles in the middle three rows of each replication, and calculating the number of insects per acre. In 1934, data was secured by counting 100 plants, picked at random, that had been dusted with each material. In the first two replications, 33 plants were counted, and in third, 34. The number of insects found was calculated per acre, as in 1933.

In 1934, the replications of each material were arranged by random distribution in order that the data might be analyzed statistically. The method of statistical analysis used is known as Fisher's t.

To obtain information on burning of foliage, the poisons applied in the field were closely observed during the season for injury. Special foliage tests were made on a small area of tobacco on the University farm where three applications of poisons were dusted heavily.

The only sprays used were in preliminary tests in 1933, and these were applied to only a small acreage and not replicated.

EFFECT ON FOLIAGE.—Tests under field conditions showed no burning of foliage from applications of the following materials at the rates indicated: Calcium arsenate, 12.5 pounds per acre; Dutox, 15 pounds; natural cryolite, 15 pounds; synthetic cryolite, 14 pounds; and lead arsenate, 7.5 pounds. Paris green, however, caused burning when used at only 2.3 pounds per acre.

Foliage tests were performed in 1934 with three brands of calcium arsenate (each diluted with 50% hydrated lime), two brands of synthetic cryolite (each diluted with 50% talc), Dutox, and natural cryolite (each diluted with 50% talc), and Paris green (diluted with various carriers). Three applications of each poison were made. For the first two applications the plants were "whitened" with dusts, but in the third the leaves were heavily coated. Burning with Paris green mixtures appeared after the second treatment and was very severe. Slight burning appeared after the third dusting with both brands of synthetic cryolite and with all three brands of calcium arsenate. No injury was found from the use of Dutox or natural cryolite.

Other workers, although admitting the good insecticidal properties of calcium arsenate, have not recommended its use on tobacco for fear of foliage injury from certain brands (Morgan, 1923). During the past 15 years, however, much progress has been made in perfecting and standardizing calcium arsenate, especially for the elimination of water-soluble arsenic. In our field tests, the "Delta" brand, sold by the Commercial Chemical Company, was used, and no foliage injury observed except under extreme conditions.

FIELD TESTS AGAINST FLEA BEETLE.—The data obtained on tobacco flea beetle control for 1933 and 1934 are summarized in Table 1. The average rates of application of the various materials, and the number of insects found, were as follows: In 1933, no treatment 41,027 beetles; Dutox 9.1 pounds, 6,034 beetles; calcium arsenate 7.6 pounds, 11,150 beetles; natural cryolite 9.5 pounds, 12,770 beetles; lead arsenate 4.9 pounds, and showed about half as many beetles as the check plot. In 1934, no treatment 82,475 beetles; Dutox 8.4 pounds, 24,299 beetles; calcium arsenate 7.2 pounds, 20,004 beetles; natural cryolite 8.6 pounds, 28,444 beetles. Synthetic cryolite applied at 10 pounds per acre gave poor results, with 37,408 beetles per acre. Paris green was used only on one sub-plot, at an average rate of 3.2 pounds, and had 33,973 beetles per acre. Lead arsenate applied at 5 pounds per acre showed about half as many beetles as untreated plants. Statistical analysis of the 1934 data shows that there is no significant difference between the number of flea beetles found on plants dusted with Dutox and those dusted with calcium arsenate; or between results with Dutox and with natural cryolite. Analysis does show a significant difference, however, between the results with calcium arsenate and natural cryolite, with synthetic cryolite and Dutox, and with synthetic cryolite and calcium arsenate.

TABLE 1. SUMMARY OF RESULTS ON CONTROL OF TOBACCO FLEA BEETLE FOR 1933 AND 1934

Poison dusts	1933		1934	
	Average number lbs. poison used per acre	Average number beetles found per acre	Average number lbs. poison used per acre	Average number beetles found per acre
Dutox	9.1	6,034	8.4	24,299
Natural cryolite	9.3	12,770	8.6	28,444
Calcium arsenate	7.6	11,150	7.2	20,004
Lead arsenate	4.9	21,176	5.0	47,010
Check[1]	—	41,027	—	82,475
Synthetic cryolite	—	——	10.0	37,408
Paris green[2]	—	——	3.2	33,973

[1]Check, or untreated, plots were the same size as other plots. After counts were made the check plots were dusted with poison.

[2]Paris green was used only on one replication and data are not exactly comparable with other materials.

FIELD TESTS AGAINST TOBACCO HORNWORMS.—In 1933, hornworms were scarce and only three applications of poisons were made, whereas in 1934 they were very severe and five treatments were made.

The data obtained on tobacco hornworm control for 1933 and 1934 are summarized in Table 2. The best control was obtained with lead arsenate and calcium arsenate. The two materials showed approximately the same degree of control, even though the lead arsenate was used at about three pounds less per acre. Dutox was used at the rate of 9.1 pounds and 10.1 pounds per acre in 1933 and 1934, respectively. Control, however, was poor in 1934, probably due to the heavier infestation. Natural cryolite used at about same rate as Dutox showed similar results. Synthetic cryolite was used in 1934 at the rate of 11.3 pounds per acre and showed fair control, with 2254 worms, as compared with calcium arsenate applied at 9.1 pounds, with 1597 worms. Paris green, applied in 1934 at the rate of 3.2 pounds on one sub-plot, showed only 985 worms, while lead arsenate used at rate of 6.1 pounds showed 1437 worms. Statistical analysis of the 1934 data shows that there is no sig-

nificant difference between the results from lead and calcium arsenates, but that there is a significant difference shown for calcium arsenate when compared with Dutox, natural cryolite and synthetic cryolite.

TABLE 2. SUMMARY OF RESULTS ON CONTROL OF TOBACCO HORNWORMS FOR 1933 AND 1934

Poison dusts	1933		1934	
	Average number lbs. poison used per acre	Average number worms found per acre	Average number lbs. poison used per acre	Average number worms found per acre
Dutox	9.1	930	10.1	3,745
Natural cryolite	9.3	1,178	10.7	3,266
Calcium arsenate	7.6	477	9.1	1,597
Lead arsenate	4.9	618	6.1	1,437
Synthetic cryolite	—	—	11.3	2,254
Paris green	—	—	3.2	985
Check	—	3,780	—	3,736

In 1933, small tests were made with sprays of calcium arsenate, lead arsenate, and natural cryolite, at the rate of 3 pounds to 50 gallons of water. Two stickers, flour and goulac (dry lignin pitch), were used with natural cryolite. Lime was used with calcium arsenate. The data obtained (Table 3) show that sprays gave good control against flea beetle and hornworm. Lead arsenate spray gave the best control of hornworm and nearly as good control as natural cryolite plus flour for the flea beetle. Calcium arsenate spray gave nearly as good results as lead arsenate and practically the same control for flea beetle as natural cryolite.

TABLE 3. SUMMARY OF SPRAY DATA ON CONTROL OF TOBACCO HORNWORM AND TOBACCO FLEA BEETLE FOR 1933

Poison sprays	Strength Lbs.-Gals.	Average number flea beetles found per acre	Average number hornworms found per acre
Natural cryolite	3–50	7,942	415
Calcium arsenate plus Lime	3–50 6–50	7,663	162
Natural cryolite plus Goulac	3–50 .3–50	13,559	232
Natural cryolite plus Flour	3–50 .3–50	7,057	255
Lead arsenate	3–50	9,061	116
Check		36,127	814

In 1934, derris and pyrethrum were used in preliminary field tests for control of tobacco flea beetle and hornworms. Some of the applications showed a temporary reduction in number of insects. Derris root dust, containing .75 per cent rotenone, was found to act quickly on flea beetles, but after the second day beetles appeared again on plants even though derris was still on the leaves. To determine how long derris retained its toxicity when exposed to climatic conditions, an experiment was performed as follows: Small leaves were removed from tobacco, placed in vials with water, and dusted heavily with derris dust containing .75 per cent rotenone. They were then placed in direct sunlight. Each evening at 5 o'clock the leaves were removed to the insectary for protection from rain, and at 7 a. m. they were again placed outside. Each day for five days a dusted leaf was removed and placed in a cage with flea beetles and the kill noted. It was found that derris lost its toxicity rapidly upon exposure, giving 100 per cent kill the first day, 55 per cent the second, and 25 per cent the third. Data are shown in Table 4.

TABLE 4. RESULTS OF AN EXPERIMENT WITH TOBACCO FLEA BEETLE SHOWING LOSS OF TOXICITY OF DERRIS WHEN EXPOSED TO THE WEATHER

No. days exposed	No. insects used	Per cent kill in days				
		1	2	3	4	5
1	25	16	56	84	100	—
2	25	10	45	55	55	55
3	20	4	4	8	20	20
4	25	0	0	12	12	12
5	25	0	4	4	4	4

Hornworms were not much affected by either derris or pyrethrum, even with heavy applications of poisons. A typical example of control of flea beetle and hornworm in the field with derris and pyrethrum is shown in Table 5. Cage tests with hornworms indicated that derris was not toxic to hornworms. Some repellent action was shown, however, since the worms would not eat dusted leaves until they had been exposed for four days. Pyrethrum was found to kill hornworms only by contact when it was fresh. Pyrethrum, like derris, deteriorates rapidly upon exposure to sunlight.

TABLE 5. RESULTS OF DERRIS AND PYRETHRUM APPLIED TO CONTROL FLEA BEETLES AND HORNWORMS ON JUNE 15, 1934

Material	Amount dust used per acre	Number beetles found			Number worms found		
		Before dusting	June 16	June 19	Before dusting	June 16	June 19
.20 per cent pyrethrum	25.7	106	114	501	9	8	16
.50 per cent pyrethrum diluted with talc	26.1	131	83	527	6	5	24
Derris (.75 per cent rotenone)	10.3	146	2	204	2	7	4

SUMMARY

1. Of the materials tested on tobacco, including lead arsenate, calcium arsenate, natural and synthetic cryolite, Dutox, and paris green, the only one to show serious foliage injury was paris green. The calcium arsenates on the market today represent a vast improvement over those manufactured 15 years ago.

2. Flea beetles were most successfully controlled by Dutox or calcium arsenate.

3. Against the tobacco hornworm, lead arsenate was slightly better than calcium arsenate.

4. Calcium and lead arsenates and synthetic cryolite when used as sprays gave about same relative degree of control of hornworms as dusts. Against flea beetle the sprays showed no great difference.

5. Derris and pyrethrum are not satisfactory for control of hornworms or flea beetles.

6. In view of the freedom from foliage injury, the elimination of residual lead, low cost, and the high efficiency in the control of both flea beetle and hornworm, the most satisfactory insecticide for dusting tobacco appears to be calcium arsenate.

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COMMERCIAL PRODUCTION OF PACKAGE BEES AND QUEENS IN THE UNITED STATES IN 1934

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Queen bees with attendant workers were imported into the United States from Italy as early as 1859, and they were shipped by mail in the United States during the same year.[2] However, the shipment of package bees was not attempted until it was suggested by A. I. Root in 1879. His suggestion was "that bees might be shipped in a cage made of common dish-screen, provided with a wooden bottom and supplied with candy and water." As an experiment E. M. Hayhurst constructed a screen cage and shipped a half-pound of bees and a queen to A. I. Root. "They were received without the loss of a single bee."[3] The production and shipment of package bees and queens have gradually increased since 1879.

The prices of package bees have varied from three dollars ($3.00) a pound to as low as thirty cents ($.30) a pound in 1933. The low prices in 1933 were below the cost of production. The depression prices in 1933 came at a time when the United States government was beginning to plan legislation that might bring the price of agricultural products to a parity with those of industrial products. This resulted in Congress passing a Federal law known as the Agricultural Adjustment Act, which was approved by the President on May 12, 1933. This act carried provisions for marketing agreements.

In July of 1933, the State Bee Inspectors of the Southern States and the leading southern package bee and queen shippers met in their respective states and selected representatives to attend a called meeting in New Orleans, Louisiana, in November. At this meeting the organization of the Bee Shippers Federation was perfected and plans were formulated to request the Honorable Henry A. Wallace, Secretary of Agriculture at Washington, D. C. to arrange a public hearing looking toward the establishing of a Marketing Agreement under the Agricultural Adjustment Act. The Secretary designated Wednesday, December 13, 1933, Convention Hall, Monteleon Hotel, New Orleans, Louisiana as the time and place for such a hearing. At this hearing the shippers of package bees and queens proposed that a Marketing Agreement for the Shippers of Package Bees and Queens be established. The Secretary accepted this proposal and executed a "Marketing Agreement and License for Shippers of Package Bees and Queens Produced in the United States," May 2, effective May 6, 1934 at 12:01 A. M., E. S. T. It is Marketing Agreement Series—Agreement No. 43, License Series—License No. 54.

Previous to 1933 there had been several efforts among the shippers of package bees and queens to agree on a minimum schedule of prices. All of these efforts had failed. At the New Orleans meeting of the Bee

[1]Managing Director of the Bee Marketing Agreement.
[2]American Bee Journal, Vol. LXXV, No. 1, January, 1935 (Reprint, p. 22).
[3]American Bee Journal, Vol. LXXV, No. 1, January, 1935 (Reprint, p. 23).

Shippers Federation, December 13, 1933, a gentleman's agreement on prices for 1934 was established. These prices prevailed until December 1, 1934, at which time the prices recommended by the Control Committee of the Marketing Agreement and License for Shippers of Package Bees and Queens Produced in the United States were approved by the Secretary of Agriculture and were declared in effect. Further revisions of prices were approved January 18, 1935.

There has been a desire to know something about the volume of business of package bees and queens produced in the United States. With this marketing agreement in effect such information has been compiled in the office of the Managing Director from the regular monthly reports. The distribution of the volume of business by states is in Table 1. The total value of the 240,180 queens and the 262,023 pounds of bees sold in 1934 was $352,843.34.

TABLE 1. PACKAGE BEE AND QUEEN VOLUME OF BUSINESS, BY STATES, IN 1934

State	Queens					Package bees	Nuclei*
	Untested	Virgin	Purely mated	With pkgs. and nuclei	Total	Number	Number
Alabama	37,542	0	13	26,807	64,362	27,674	252
Arkansas	390	0	0	97	487	92	5
California	19,290	0	3	12,574	31,867	13,021	20
Connecticut	1,554	0	0	14	1,568	6	8
Florida	2,342	0	0	385	2,727	385	0
Georgia	9,482	0	0	14,793	24,275	15,144	81
Illinois	481	0	0	831	1,312	851	3
Indiana	1,400	0	61	0	1,461	0	0
Iowa	218	0	0	4	222	0	4
Kentucky	1,218	0	0	0	1,218	0	0
Louisiana	9,468	0	2	14,058	23,528	15,128	226
Maryland	26	0	0	0	26	0	0
Michigan	1,291	12	6	13	1,322	1	12
Mississippi	19,847	0	0	24,096	43,943	24,908	7
Missouri	600	0	0	2	602	9	0
Nebraska	29	0	0	11	40	11	0
New Jersey	1,666	0	11	104	1,781	99	5
New York	987	0	0	0	987	0	0
North Carolina	1,203	0	36	10	1,249	10	0
Ohio	8,569	0	0	2,550	11,119	2,550	0
Oregon	1	0	4	0	5	0	0
Pennsylvania	1,750	0	0	0	1,750	0	0
South Carolina	1,758	0	0	708	2,466	743	0
Tennessee	1,331	0	0	79	1,410	69	10
Texas	12,410	0	10	7,428	19,848	7,709	327
Wisconsin	285	0	0	320	605	320	0
Total	135,138	12	146	104,884	240,180	108,730	960

*Comb packages.

SOME REMARKS CONCERNING THE EGG PARASITE, *TRICHOGRAMMA MINUTUM* RILEY, IN FLORIDA

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An attempt at biological control of the celery leaf tier (*Phlyctaenia rubigalis* Guen.) by means of *Trichogramma minutum* Riley in the celery fields near Sanford, Fla., during the period 1928–1932 led to the discovery of a new race of the parasite and furnished occasion for making some observations on the habits and development of the parasite under conditions found in the Sanford, Fla., district.

A NEW RACE.—Entomologists have described a number of races among various species of insects in recent years. This subject has been dealt with by Thorpe (*13*).[1] One of the first notices of more than one race of the *minutum*-like species of *Trichogramma* was published in 1911 by Howard and Fiske (*6*), who were working with the parasites of the gipsy moth (*Porthetria dispar* L.) and the brown-tail moth (*Nygmia phaeorrhoea* Don.) in Massachusetts. They found that the American form with which they were working was arrhenotokous and the European form thelyotokous. In 1926 Martin (*9, pp. 112, 122*), in northern Michigan, noted a black race having males with normally vestigial wings. In 1927 Marchal (*8*), in France, wrote of color differences and noninterbreeding races. Peterson (*10*), in 1930, working with the parasites of the oriental fruit moth (*Grapholitha molesta* Busck) and of the codling moth (*Carpocapsa pomonella* L.), described two species, or races, of *Trichogramma* which showed color differences dependent upon the temperature at which they were reared, which differed in the time required for complete development and in flight habits, and which would not interbreed. In 1930 and 1931 Flanders (*4, 5*) described five races from various parts of the United States and Mexico having very apparent differences in color and length of life cycle when reared in eggs of the Angoumois grain moth (*Sitotroga cerealella* Oliv.) at a constant temperature of 60°F.

A thorough search for the hosts of *Trichogramma minutum* in Florida has resulted in the discovery of another race which is a parasite in the eggs of *Calpodes ethlius* Cram., a common feeder on the leaves of canna and other swamp lilies throughout the southern part of the United States. Dozier (*2*) reported rearing, from *Calpodes* eggs in Haiti, a strain which is similar to the Florida race except that it was reported to be "almost brown" in color.

Counting Martin's black race having males with normally vestigial wings, Flanders' five races, and the new one here reported, there are today at least seven recognized races of *Trichogramma minutum* in America. This adds to the complexity of the problem of biological control with this parasite.

Eggs of *Calpodes ethlius* parasitized by the new race of *Trichogramma minutum* were first taken at Tampa, Fla., on August 12, 1927. Observations and experiments each year since that date have shown this race to differ from the one usually found in eggs from wild host plants about the celery fields in central Florida. The common race is, at summer temperatures, a yellowish form varying to somewhat darker in winter, and parasitic in the eggs of the celery leaf tier and many other insects. The *Calpodes* race is black or fuscous throughout the year at all temperatures and seems to be very limited in its range of hosts when compared with the yellow race. It consistently refused, or was unable, to parasitize other eggs upon which it was tried in more than 30 separate experiments which included trials with eggs of the celery leaf tier (*Phlyctaenia rubigalis*), the Angoumois grain moth (*Sitotroga cerealella*), the Indian meal moth (*Plodia interpunctella* Hbn.), the Mediterranean flour

[1]The numbers in italics refer to Literature Cited at end of paper.

moth (*Ephestia kuehniella* Zell.), and the imperial moth (*Basilona imperialis* Drury). Recently, however, a single instance of successful parasitization of celery leaf tier eggs occurred in the laboratory. It is certain that this very rarely occurs in the field, for of thousands of emergences from eggs taken on celery in the field not a single instance has yet been observed of the black race of *Trichogramma* emerging from celery leaf tier eggs. A black *Trichogramma* closely similar to, if not identical with, the Calpodes race has been taken emerging from occasional eggs of *Phlyctaenia tertialis* Guen. found on elderberry growing in the midst of patches of canna lilies.

The two races differ somewhat in size and in their oviposition habits. The *Calpodes* race is larger and more robust, probably because of the larger host eggs from which it emerges. In oviposition the female of the *Calpodes* race, bracing herself between the side of the egg and the leaf surface, drills with her ovipositor at an angle into the side of the egg. The female of the yellow race takes a position anywhere on the crown or summit of the host egg and drills directly downward with her ovipositor.

Several attempts to get the two races to interbreed have failed. In one instance a male of the yellow race persisted in attempts to mate with a female of the *Calpodes* race, but she as persistently resisted until he ceased his efforts.

Morphologically these yellow and black races from Florida are indistinguishable. The males and females of both races normally have well developed wings. Specimens of the *Calpodes* race collected both at Tampa and at Sanford, Fla., have been identified by A. B. Gahan, of the U. S. Bureau of Entomology, as *Trichogramma minutum* Riley.

Eggs parasitized by the *Calpodes* race were collected in several localities at intervals over a period of about one year, and data secured on the emergence. From 160 of these as few as 7 and as many as 22 adults, with an average of 12.52, emerged from individual eggs. In the egg from which the 22 adults emerged there were 3 males and 19 females. The proportion of the sexes ranged from no males and all females in three eggs to a maximum of 15.75 per cent males, with an average of 14.16 per cent males out of 2,003 adults which emerged. The average for the yellow race from various hosts was 28 per cent males out of 1,430 adults. The percentage of parasitization of all *Calpodes* eggs collected during the time in which this parasite has been under observation has ranged from 0 to a maximum of 100 per cent, with an average of 66⅔ per cent. In nearly all cases the parasites emerged through a single opening in the chorion. Three eggs were seen with two emergence holes each. Usually all the parasites within a single egg emerged on the same day, but during cooler weather emergence sometimes extended over three days.

Winter Activity of Trichogramma as a Parasite of the Celery Leaf Tier.—Peterson (*11*), working in New Jersey, has given us our first definite information on the natural overwintering of *Trichogramma minutum*. He states that his observations "show conclusively that the species passes the winter as partly developed individuals within dark-

ened host eggs." He further reports that some adults may emerge out of doors on warm days in December and January, but that the probability of their finding nonparasitized eggs in which to oviposit before they perish is slight. The question of the winter habits of *Trichogramma minutum* in the Sanford, Fla., area is important owing to the fact that an attempt is being made to utilize the parasite in the control of the celery leaf tier, which normally develops during the winter season. It is possible to find parasitized eggs of the celery leaf tier or of other hosts in or near the celery fields on almost any day during the winter months. There are, however, periods when the activity of the parasites is so lessened that it is very difficult to find evidence of their presence in the fields.

To obtain information on the activity of the parasite during the winter months, plants bearing fresh eggs of the celery leaf tier were placed daily in various locations in the celery fields from December 1930 to March 1931, inclusive. These plants, after they had been in the field several days, were taken into the laboratory and examined for parasitized eggs. The average monthly percentages of parasitization found are shown in Table 1 together with the monthly mean temperatures for this season as compared with the average monthly mean temperatures for the district.

TABLE 1. AVERAGE PARASITIZATION (BY MONTHS) OF CELERY LEAF TIER EGGS BY *Trichogramma minutum*, AND TEMPERATURES FOR THE CORRESPONDING PERIODS, SANFORD, FLA.

Month	Average monthly parasitization, 1930–31 *Per cent*	Monthly mean temperature, 1930–31 °F.	Average monthly mean temperature °F.	Month	Average monthly parasitization, 1931 *Per cent*	Monthly mean temperature, 1931 °F.	Average monthly mean temperature °F.
November.....	39.20	66.0	66.0	March....	1.26	60.6	65.8
December.....	3.11	57.4	61.0	April	1.46	68.5	70.4
January.....	.75	58.0	60.1	May.....	10.72	75.8	75.6
February.....	.95	60.6	62.7	June.....	9.00	80.8	79.7

The celery-growing season of 1930–31, as will be noted in Table 1, included an unusually cold winter. In spite of the exceptionally long period of cold weather there was some activity throughout the season. Observations during more favorable seasons, however, have not shown such a definite decrease in activity.

No doubt many factors operated to limit the activity of the parasites during the winter season of 1930–31. The cold weather was severe enough and of sufficient duration to retard the development of all the hosts. Even the celery leaf tier, which is expected to thrive at this time of the year, was extremely scarce. The abundance and particularly the distribution of the host eggs is important inasmuch as all available evidence indicates that the dispersion of *Trichogramma* is restricted to a limited area around the point of emergence.

Emergence of the parasite is known to occur in the field at temperatures as low as 60°F., and oviposition takes place at temperatures of 63° and above. Parasites have been seen to emerge and oviposit within two hours after the temperature rose to 63°F. The generations so overlap that individuals may be found in all stages of development, and some will always be ready to emerge whenever conditions are suitable. It

might be expected, then, that whenever the temperature rose to about 65°F. and remained there for a short time, it would be possible for parasites to emerge, and to oviposit provided host eggs were easily available. The infestation of the most important host, the celery leaf tier, was extremely light during the winter of 1930–31, so it is probable that a large percentage of parasites emerging failed to find hosts for oviposition.

Figure 118, showing the daily maximum and minimum temperatures from Nov. 15, 1930, to Apr. 15, 1931, is offered to indicate the number of times during that season when temperature conditions might have been high enough to permit emergence and oviposition.

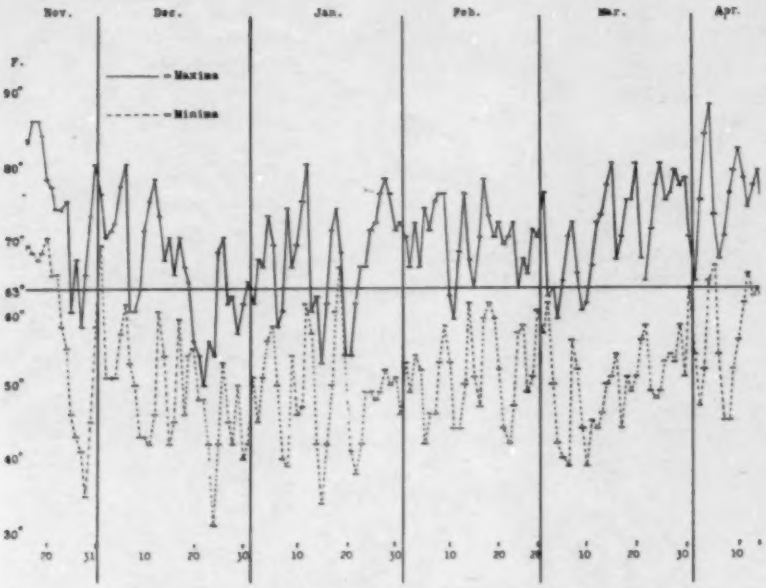

FIG. 118.—Daily maximum and minimum temperatures, Sanford, Fla., Nov. 15, 1930, to Apr. 15, 1931.

The line at 63°F. indicates what is considered as the minimum temperature for oviposition by *Trichogramma* in the field, but what may be considered as active oviposition, based on observations under favorable conditions, is not noticeable until the temperature has reached about 70°F.

The southern limits of the general cyclonic storms during winter months extend into Florida, and these cause alternating periods of warm and cold days, and the frequency and length of the favorable warm periods have a determining effect on the parasitization by *Trichogramma*. During the winter of 1930–31 the warm days were not nearly so pronounced as is usually the case. Indications of them, however, can be seen in the figure.

A study of conditions prevailing during the celery season of 1930–31 and of observations made at various other times indicates that the low percentages of parasitization during the months of January to April were the result of a combination of factors, the most important of which have been discussed. Temperature was probably not so important as a direct limiting factor in the activity of the parasites because there seem to have been plenty of opportunities during each month for the adults to emerge and oviposit as far as temperature alone is concerned. In the season under discussion the length of the favorable periods was shorter or their occurrence less frequent than usually would be the case. The excess of cold weather probably retarded development of the parasites in the host eggs to an appreciable extent. This effect does not, however, appear to be so important as the effect of the temperature on the development of the hosts. When it is realized that the activity of all insects commonly present during the winter was less than had been noted for years, it is easy to see that the adult parasites which emerged during favorable periods had little chance of finding an opportunity to oviposit.

MASS PRODUCTION.—Mass production of *Trichogramma* was conducted during the seasons of 1928 to 1932 by methods similar to those outlined by Flanders (*3*) and others. A constant fight against pests of one kind or another has been necessary in order that efficient production might be attained, but the elimination of all pests has been impossible. The rearing has been done in the basement of a public building where it would be dangerous and very inconvenient to fumigate or properly treat the materials used. A relative freedom from pests is possible only with the utmost vigilance and the very best of equipment in an insect-proof laboratory. The use of heat, which is considered the most reliable method of treatment for the corn to be used in the rearing rooms, has been only partially successful. In spite of all precautions mites of the genus *Seius*, the host used in the mass rearing of *Trichogramma*, attacking both the eggs and adults of the Angoumois grain moth, have caused considerable trouble. The rice weevil (*Sitophilus oryzae* L.), which devours or spoils the grain, and the rust-red flour beetle (*Tribolium ferrugineum* Fab.), which eats not only the grain but also the eggs of the host moth, have been serious pests in the breeding rooms, eventually either stopping the production of moths or at least greatly diminishing it. In addition, they shorten the time during which the corn is suitable for breeding purposes.

Treatment of the grain with sulphur was tried against the predatory mites and discarded. It prevented development of the young mites but did not kill the older ones. The sulphur apparently did not interfere with the production of the Angoumois grain moth, but it was very difficult to rear *Trichogramma*, especially after the second and third generations, from eggs of the moths which developed in the corn treated with sulphur. Varying the proportions of sulphur mixed with the grain made little if any difference. Alden (*1*) and List (*7*) reported similar experience with the use of sulphur.

When the production of *Trichogramma* was found to be difficult because of the sulphur treatment for mites it was at first thought that the stocks of *Trichogramma* that were being used had possibly lost their vigor because of constant rearing indoors. New stocks were secured from the field, but they gave no better results. Different humidities, ventilation, refrigeration of host eggs and of the parasites for various lengths of time and at different temperatures, various types of cages, various positions of the cages with respect to the sources of light, colored lights, and ultra-violet light all were tried. Most of these proved to be of no importance, but production of parasites immediately improved when corn containing no sulphur was used. Refrigeration of the host eggs at times gave some encouragement, but failed at other times when repeated under the same conditions.

When *Trichogramma* adults were given ultra-violet ray treatments ranging from 15 seconds to 10 minutes, the life was shortened somewhat under the longest exposures. Stocks of parasites maintained outdoors, exposed to the natural ultra-violet light, and indoors, entirely protected from it for 74 generations, showed no differences. Parasites, the progeny of a single female, inbred for 66 continuous generations indoors, showed no weakening or lack of vigor.

Cages of the type most convenient for rearing *Trichogramma* under conditions most nearly natural were found to consist of pasteboard ice-cream boxes or other similar cylindrical containers which had the ends covered with transparent cellulose permeable to atmospheric moisture and ultra-violet light. Parasitized and unparasitized eggs, attached by means of paste or a thin coat of shellac to strips of light cardboard, were looped about inside the cylindrical walls.

Storage of host eggs in an electric refrigerator with a temperature range of 36° to 48°F. until needed for oviposition by *Trichogramma* proved to be impractical for more than about three weeks because of desiccation. Eggs of *Sitotroga* when so stored for about 10 days would not hatch and yet were parasitized by *Trichogramma* even more readily than those that were fresh or stored for only a few hours. A large proportion of the *Trichogramma* pupae within their host eggs, when stored in the electric refrigerator, were found to be unable to survive more than about one month without protection from desiccation. Those protected in tightly enclosed receptacles like fruit jars survived about one week longer. Those kept in vessels with moisture, or in a refrigerator containing considerable moisture, were subject to mold. It was difficult to keep sufficiently low temperatures for successful storage in an ice box. Peterson (*12*) recently reported similar experiences.

FIELD EXPERIMENTS.—A review of the methods used in celery culture in the Sanford, Fla., area should help to an understanding of the principal factors concerned in the utilization of *Trichogramma* as an aid in the control of the celery leaf tier. The crop is grown during the winter season, September to May, and usually on areas of several hundred acres in one almost continuous, large field. Each area consists of a group of farms which may be divided into smaller fields by railways, roads, building lots, drainage ditches, or patches of timber. The smaller fields are

subdivided by roads and pipe lines into blocks which are about 100 yards wide and extend back various distances from the roads at the edges of the fields, so there may be up to 10 or 20 acres in each block. Most of the land is subirrigated by means of artesian wells and tile drainage systems in order to keep the moisture content of the soil fairly constant. The seed is planted any time from late July until January in slightly elevated, irrigated, and shaded seed beds. From four to six weeks later the young plants are transplanted into one of the field blocks, usually in single rows 30 inches apart and spaced 3 to 4 inches in the row. Skill, constant care, and considerable expense in the way of irrigation, fertilization, cultivation, and application of fungicides and insecticides are necessary throughout the entire period of growth. When the celery is nearly mature it is bleached, in most cases for a few days before harvest, by placing heavy strips of paper on each side of the row. The harvest, which follows about four months after the young plants are set in the field, may occur at any time between the latter part of December and early June. Blocks of the older, more mature celery are situated often beside younger, more recently planted ones, and the harvesting of the mature blocks leaves increasingly larger intervening spaces without celery as the season advances. These spaces are planted with various cover crops or develop growths of weeds or grasses during the following summer. The proximity of the older and younger blocks of celery has an important bearing because of the migration and concentration of insects from the harvested blocks into those that remain. Various methods of handling during harvest prevail, but the ordinary procedure is to haul the celery, with any insects which may be on it, to a packing house, where it is washed, packed into crates, and shipped to market in refrigerator cars.

Two methods of liberating *Trichogramma* in the field were tried. In the first method cardboard strips bearing the parasite pupae nearly ready to emerge were placed directly in the celery rows, or suspended a few inches above them in inverted paper cups on large wire staples such as are employed in supporting the paper used for bleaching the celery. The purpose of the cups and of their suspension on the wire staples was to protect the emerging parasites from rain and to make them less accessible to the numerous predators, such as cockroaches, ground beetles, lady-bird beetles, and the larvae of lacewing flies. The method of suspension in cups required the use of considerable material and did not give reliable protection against predators. By the second method, which seems preferable, the parasites were liberated in the field as adults during the morning of their emergence.

In all the field experiments the parasitization was estimated by actual count of the parasitized and unparasitized eggs which were found on individual celery plants selected from various locations in the field. In nearly all fields some natural parasitization took place, and this had to be considered in estimating percentages and the effects of liberations. All selected control blocks of celery were one fourth mile or more from the experimental blocks where parasites were colonized. As far as possible the counts from experimental blocks and those from the control

blocks were made on the same dates, to avoid any differences which might be due to changing weather, progress of generations, or other cause.

The first field liberations of *Trichogramma* were made on April 14, 1928, when a total of 100,000 parasites were distributed in four widely separated blocks of approximately 1 acre each. Particular note was made of their dissemination from the points of liberation and of the increase in parasitization. Five colonies of 10,000 parasites each were placed at intervals of 20 feet across one of these blocks. The data secured on the dissemination of the parasites with respect to distances from the points where the colonies were liberated, the numbers of plants on which counts were made, the numbers of eggs per plant, and the percentages of parasitization two weeks after liberation are shown in Table 2. The data secured on the colonization in the other three blocks were similar to those for the block shown in this table.

The figures given in this and the following tables are presented merely to show the results obtained in the colonization of *Trichogramma* as a possible control for the celery leaf tier in Florida. It is recognized that the results obtained cannot be considered as conclusive. The number of plants in the samples taken was limited on account of the labor and time necessary to count the eggs and is not large enough to furnish data from which definite conclusions could be drawn.

TABLE 2. DISSEMINATION OF *Trichogramma* FROM POINTS OF LIBERATION IN A CELERY FIELD, SANFORD, FLA., 1928

Distances from liberation point *Feet*	Number of plants examined	Total host eggs	Host eggs per plant	Parasitized eggs	Parasitized eggs per plant	Parasitization *Per cent*
0	10	49	4.9	14	1.4	28.57
5	11	46	4.18	15	1.4	32.6
10	2	11	5.5	7	3.5	63.6
18	8	32	4.0	6	.75	18.75
100	4	7	1.75	4	1	57.14
Total	35	145	—	46	—	—
Average	—	—	4.14	—	1.3	31.7

The increase in parasitization due to the natural parasitization already present and the increases in parasitization where the colonizations were made are shown in Table 3.

TABLE 3. INCREASES IN PARASITIZATION OF CELERY LEAF TIER BY *Trichogramma* ON APRIL 30, 1928, AFTER COLONIZATION OF THE PARASITE IN A CELERY FIELD AT SANFORD, FLA., ON APRIL 14

Block	Date 1928	Number plants examined	Total host eggs	Host eggs per plant	Parasitized eggs	Parasitized eggs per plant	Parasitization *Per cent*	Increase *Per cent*
Experimental	4/14	6	76	12.6	1	.166	1.30	——
Experimental	4/30	35	145	4.14	46	1.31	*31.72*	30.42
Control	4/14	8	68	8.5	3	.375	4.41	——
Control	4/30	11	16	1.4	5	.45	*31.25*	*26.84*
Net increase in experimental over control block								3.58

Field liberations in 1929 were made in three blocks at least 1 mile apart. About 700,000 parasites were used, and attention was directed again to dissemination and increase of parasitization. Tables 4 and 5 present the data secured from one of these blocks in which 400,000 *Trichogramma* were liberated on February 28 in 80 colonies of 5,000 each

spaced at intervals of 36 feet. In this block the increase in parasitization was 30.8 per cent greater than that in the control. In another block where 5,000 parasites were liberated in January the increase in parasitization was 7.2 per cent higher in the control than in the experimental block, and in a block where 235,000 parasites were liberated in April the increase in the control was greater by 14.4 per cent.

TABLE 4. DISSEMINATION OF *Trichogramma* FROM POINTS OF LIBERATION IN A CELERY FIELD, SANFORD, FLA., 1929

Distances from liberation point *Feet*	Number of plants examined	Total host eggs	Host eggs per plant	Parasitized eggs	Parasitized eggs per plant	Parasitization *Per cent*
0	40	579	14.47	346	8.65	59.76
2.5	16	95	5.93	40	2.5	42.10
5	9	63	7	5	.55	7.93
7.5	29	168	5.79	34	1.17	20.24
12.5	4	8	2	5	1.25	62.50
Total	98	913	—	430	—	—
Average	—	—	—	—	4.39	47.1

TABLE 5. INCREASE IN PARASITIZATION OF CELERY LEAF TIER BY *Trichogramma* ON MARCH 12, 1929, AFTER COLONIZATION OF THE PARASITE IN A CELERY FIELD AT SANFORD, FLA., ON FEBRUARY 28

Block	Date 1929	Number plants examined	Total host eggs	Host eggs per plant	Parasitized eggs	Parasitized eggs per plant	Parasitization *Per cent*	Increase *Per cent*
Experimental	2/28	10	230	23.0	31	3.10	13.48	—
Experimental	3/12	98	913	9.31	430	4.39	*47.10*	33.62
Control	2/28	19	479	25.21	2	.105	.418	—
Control	3/12	12	186	15.5	6	.50	*3.22*	*2.8*
Net increase in experimental over control block								30.8

During the spring of 1930 the infestation by the celery leaf tier was very light. No liberations of *Trichogramma* were made until near the end of the celery season, in April, when 10 rows of celery surrounded by bare land from which the earlier crops had been cut were chosen for experiment. As a result of the harvesting operations large numbers of moths were concentrated in these rows. There were about 10,000 celery plants with an average of almost 19 eggs per plant, or 190,000 celery leaf tier eggs in the 10 rows of celery. About 500,000 adult *Trichogramma* were liberated in this location by using the inverted cup method. The cups, each containing over 5,000 parasites, were suspended just above the celery tops and so placed throughout the entire 10 rows that there was one cup in each 8-foot square of celery. Table 6 gives the data obtained from this colonization and shows that although nearly three times as many parasites were liberated as there were host eggs present, not all the eggs were parasitized, although a good increase in parasitization was obtained.

TABLE 6. INCREASES IN PARASITIZATION OF CELERY LEAF TIER BY *Trichogramma* ON APRIL 22, 1930, AFTER COLONIZATION OF THE PARASITE IN A CELERY FIELD AT SANFORD, FLA., ON APRIL 12

Block	Date 1930	Number plants examined	Total host eggs	Host eggs per plant	Parasitized eggs	Parasitized eggs per plant	Parasitization *Per cent*	Increase *Per cent*
Experimental	4/12	22	411	18.68	42	1.91	10.21	—
Experimental	4/22	14	186	13.28	140	10.00	*75.27*	65.06
Control	4/12	15	59	3.9	1	.07	1.70	—
Control	4/22	17	53	3.12	7	.41	*13.21*	*11.51*
Net increase in experimental over control block								53.55

The celery season of 1931 was an abnormally cold one. The infestations of the celery leaf tier were so light that liberation of parasites was not practical. In no case was there enough damage by the leaf tier larvae to cause the farmers to employ control measures against them.

On the other hand the celery season of 1932 was abnormally warm. Infestations causing commercial damage occurred as early as November and continued until April. During this period nearly 600,000 *Trichogramma* were liberated, in colonies of 5,000 placed at intervals of 20 or more feet, in five different blocks of celery on successive dates, and checks made of the parasitization until the blocks were harvested. Table 7 is typical of the results obtained. The average parasitization in the experimental block was 41.55 per cent as contrasted with 11.71 per cent in the control block.

TABLE 7. INCREASES IN PARASITIZATION AFTER COLONIZATION 1932

Date 1931	Number plants examined	Total host eggs	Host eggs per plant	Host eggs per acre	Parasitized eggs	Parasitized eggs per plant	Parasitization *Per cent*
Experimental Block							
11/5		10,000 Trichogramma were liberated in this block.					
12/16	12	283	23.58	1,348,200	23	1.92	8.13
12/17		60,000 Trichogramma were liberated in this block.					
12/18	12	284	23.66	1,352,800	98	8.17	34.51
12/20	12	196	16.33	940,800	152	12.67	77.55
12/21		30,000 Trichogramma were liberated in this block.					
12/24	12	166	13.83	786,600	138	11.50	83.13
12/29	12	107	8.92	513,200	98	8.17	91.59
1932							
1/4	3	13	4.33	249,600	5	1.67	38.46
1/14	10	638	63.8	3,674,900	6	.60	.94
1/27	12	419	34.92	2,010,400	355	29.58	84.73
Total	85	2,106			875		
Average	—		24.77	1,422,609*	—	10.29	41.55
Control Block							
1931							
12/14	15	335	22.33	1,286,400	4	.27	1.19
12/15	15	293	19.53	1,124,900	2	.13	.68
12/18	15	157	10.47	602,500	16	1.07	10.19
12/20	15	219	14.60	840,500	24	1.60	10.96
12/30	15	86	5.73	328,300	41	2.73	47.67
12/31	15	26	1.73	97,900	25	1.67	96.15
1932							
1/14	3	26	8.67	495,300	4	1.33	15.38
1/22	14	554	39.37	2,279,200	50	3.57	9.03
1/30	15	883	58.87	3,390,500	141	9.40	15.97
Total	122	2,579			302		
Average	—		21.14	1,216,883*	—	2.47	11.71

*These are weighted averages.

CONCLUSIONS.—It appeared that even when large numbers of parasites were liberated within small areas there was only a small increase in the percentage of parasitization as compared to that in the control areas where no parasites had been liberated, and thickly distributed colonies of overwhelming numbers of parasites placed in celery rows when host eggs were abundant, such as are shown in Table 6, gave only a moderately high percentage of parasitization.

Although the data derived from experimental colonizations of *Trichogramma* in the celery fields have of necessity not been sufficiently extensive to warrant conclusions, the work has proceeded far enough to show that there are a number of serious difficulties in the way of the

practical use of this parasite for biological control of the celery leaf tier in Florida. Some of the difficulties are presented as follows:

(1) The celery leaf tier develops during winter months at temperatures which are unfavorable for the parasite. The minimum temperature for oviposition by the celery leaf tier is very near 50°F. as against 63°F. for *Trichogramma*, so for favorable colonization of *Trichogramma* the temperatures must be somewhat above 63°F.

(2) The celery leaf tier appears in fairly distinct generations until late in the spring of the average season; and since there are three or more generations of the parasite to one of the tier, the intervening generations of *Trichogramma* must carry over in lessened numbers on the early and late individuals of the tier generations together with the few other hosts in and around the celery fields. Consequently a building up of the parasitization is difficult.

(3) Many adult *Trichogramma* perish during each of the necessarily frequent applications of sprays or dusts for the control of disease or other pests upon the celery, and practically all are killed whenever the use of pyrethrum is required to eliminate the leaf tier larvae. Most of the tier moths escape from these treatments without severe injury.

(4) The tier moths are much stronger fliers than *Trichogramma* and distribute themselves farther and more quickly from centers of concentration to other areas.

(5) At harvest the *Trichogramma*, most of which are within their host eggs on the celery, are hauled away with the crop while the tier moths fly to adjoining fields and increase the infestations there. In this way the often heavy parasitization in the harvested field is stopped in a particular area within about two months after the celery is large enough to contain an appreciable infestation of the tier and its parasites. This procedure is repeated in adjoining areas, and there is less opportunity to profit by the cumulative effect from early colonization than is the case in a crop having a longer period of growth.

(6) There is much uncertainty as to when seasons may occur in which there will be commercial damage and control measures will be needed. During the five years of these experiments there were two in which control was not necessary and only one in which infestations were severe. In order to have parasites when needed the insectary work must be in operation several months before it can be known whether or not there will be an injurious infestation of the celery leaf tier. There will be many seasons, therefore, when the parasite material will not be utilized. This fact would add greatly to the expense of using *Trichogramma* as compared with the benefits to be secured.

(7) Present methods of artificial control are reasonably satisfactory when properly used.

It is considered that the conditions as they prevail in culture of Florida celery are not favorable for the utilization of *Trichogramma* as a control for the celery leaf tier and that mass production and colonization would be much too costly to be practical.

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CORN EARWORM NOT CONTROLLED IN SWEET CORN BY RELEASE OF TRICHOGRAMMA[1]

By W. H. LARRIMER

It seems to have been fairly well established that the egg parasite, *Trichogramma minutum* Riley, can not be utilized in a practical way and on an extensive scale to control the corn earworm (*Heliothis obsoleta* Fab.) and other similar insects in field corn. One of the difficulties seems to be a matter of distribution, particularly the tendency on the part of the parasite to spread rather slowly from the point of liberation. Small plantings of sweet corn for commercial as well as home use customarily are made at short intervals throughout the growing season in order to have a continuous supply of green corn for table use or for sale. Because of the high relative value of such crops, a reasonable expenditure of time and effort to insure earworm-free ears may be justified. It seemed possible that the tendency of the parasites to spread slowly might be turned into an advantage in concentrating them on such small commercial and garden plantings. Consequently, during the growing season of 1934, at Arlington Farm, Va., six plantings of Golden Cross Sweet

[1]The parasites used in this experiment were furnished by Dr. Herbert Spencer through the courtesy of Mr. D. L. VanDine of the Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine.

Corn were made at intervals of two weeks from May 1 to July 10. Each planting of about one-fifth acre consisted of four replicated plots, one set of duplicate plots to be used as release plots and one set to be used as a check. The first earworm eggs were available in numbers around June 14 and 15 and were present continuously through the remainder of the season. Some scarcity of eggs was observed in the middle of July, which happened to be the time the second planting was in full silk.

The first liberation of parasites consisting of 30,000 individuals was made June 5. The second liberation, of 40,000 individuals, was made July 19. Earworm eggs were collected and reared through the season both from the release and check plots and also from neighboring fields as well as fields remote from the experiment.

From one parasitized egg of a species of *Eurymus* collected on clover on May 18, there emerged on June 5 five adults of *Trichogramma minutum*. No *Trichogramma* were reared from eggs from any other source until the final collection of earworm eggs was made on the experimental plots on August 31. On the 12th of September parasites emerged from 5 of the 20 eggs taken from the release plots, indicating 20 per cent parasitization. None of the other collections, consisting of eggs from other sources made up of samples of from 12 to 50 eggs each, depending on the seasonal abundance, contained parasites. The earworm population throughout the season can best be indicated by the ear infestation in the various plots on dates shown in the accompanying table.

One hundred ears from each of the duplicate check and release plots, or a total of 400 ears, were examined for percentage of infestation in each planting.

TABLE I. DATES OF PLANTING, SILKING, AND HARVESTING OF CORN PLOTS IN *Trichogramma* CONTROL EXPERIMENT AND COMPARISON OF EARWORM POPULATIONS IN RELEASE AND CHECK PLOTS

Plot	Planted	Silking			Harvested	Infestation per cent					
		Up	Began	Full		Release			Check		
						1	2	Av.	1	2	Av.
1	May 1	May 9	July 2	July 10	July 25	91	92	92	80	86	83
2	May 16	May 23	July 16	July 20	Aug. 3	63	66	65	55	65	60
3	May 29	June 3	July 23	July 27	Aug. 10	81	86	84	85	75	80
4	June 12	June 18	July 30	Aug. 3	Aug. 20	91	87	89	80	83	87
5	June 26	July 2	Aug. 13	Aug. 18	Sept. 4	91	87	89	80	93	87
6	July 10	July 16	Aug. 31	Sept. 8	*	98	100	99	100	99	100

*Storm and flood ruined this planting during September.

As indicated by percentage of parasitization, the per cent of earworm infestation, and the earworm populations in the ears of corn, the release of *Trichogramma* had no beneficial effect whatever on earworm abundance or damage during the season.

TECHNIQUE FOR LIFE-HISTORY STUDIES OF WIREWORMS

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In a study of the life history of elaterids, extensive experimentation has been necessary in developing technique and apparatus for rearing and handling the various stages. During the years 1929 to 1933, inclusive, at Alhambra, Calif., the writer employed successfully the methods herein described in rearing to maturity large numbers of the wireworm, *Limonius californicus* Mann., and other species[2] destructive to truck crops in southern California.

REVIEW OF LITERATURE.—In 1914 Graf (*4*)[3] stated that he had obtained eggs by confining adults under a screened cage inside which had been buried several flowerpots filled with loose soil. He found petri dishes impractical for incubating eggs owing to the heavy mortality from fungi and the difficulty in regulating the moisture supply. For rearing larvae he recommended a plaster of paris, block-type cage having two compartments with soil and larvae in one and water in the other to provide moisture. He also found common root cages satisfactory when used in conjunction with other cages. Girault (*3*), in the same year, recommended Tower breeding cages, wooden boxes, and flowerpots for rearing scarabaeid larvae. He stated that the type of cage mattered little, provided they received good attention. Davis (*2*), in 1915, in his studies of white grubs, recommended flowerpots for rearing larvae and obtaining eggs. One-ounce salve cans were used successfully in obtaining records on behavior, feeding, and molting. Hyslop (*5*), also in 1915, reported that he had confined dry-land wireworms, *Corymbites noxius* Hyslop, in a root cage made by sinking a barrel to the level of the soil surface and filling it with earth. McColloch (*8*), in 1917, mentioned rearing underground insects in a cement cave 2 feet below the surface. He found 1-ounce and 2-ounce salve cans satisfactory for rearing white grubs and elaterid larvae. Roberts (*9*), in a paper published in 1919, stated that he obtained elaterid eggs by confining adults in small pots containing grass plants embedded in dark soil. Eggs so obtained were placed in damp soil on watch glasses during the incubation period. Glazed earthenware pots 5 inches in diameter and 15 inches deep were used for rearing larvae out of doors, while salve cans served the same purpose indoors. Lane (*7*), in 1924, described a chamber and equipment for rearing larvae; outlined a method of obtaining adults in numbers by use of rearing cages and by field collecting; and described mating technique, the method of recovery and handling of eggs from the soil, and the equipment used for determining the incubation period. He also explained the methods of handling, feeding, and rearing newly

[1]The writer wishes to express his gratitude to Roy E. Campbell, under whose direction the work was done, for his kindly aid and helpful criticism.

[2]*Melanotus longulus* (Lec.) and *Aeoleus livens* (Lec.).

[3]Italic numbers in parentheses refer to Literature Cited at the end of this paper.

hatched larvae, using salve cans and metal cages out of doors. Bryson (*1*), in 1929, reported that he had obtained excellent results in rearing elaterid larvae in unglazed drain tiles 6 inches in diameter and 12 inches long, buried in pairs one above the other in a trench out of doors. He described the technique of assembling such cages and the methods used in recovering specimens. He also presented data showing the positions of the various stages and the percentage of recovery, and cited advantages of this cage over previously described rearing cages. In 1929 Imms (*6*), also, recommended unglazed drain pipes for rearing wireworms out of doors.

Underground Rearing Chamber and Apparatus.—In rearing subterranean insects, particularly Elateridae, it is essential that the same conditions of temperature and moisture that prevail below the soil surface be duplicated as nearly as possible in the rearing chamber selected. The cement cave recommended by McColloch (*8*) would be most desirable if proper facilities were provided for feeding and for the care of the larvae during their development. Conditions very similar to the natural may be obtained in a well-insulated cement basement. A hygrothermograph is essential for recording temperature and humidity. To ascertain the effect of temperature on the growth and activities of the insect in all its stages, recording soil thermometers, preferably of the multiple-pen type, are necessary.

Temperature-control cabinets were employed to determine the effects of different constant temperatures on the quantity of food consumed and on the rate of development of the various stages. Also, cabinets were used to expose dormant adults for short periods to high temperatures in order to hasten mating and oviposition before such activities begin in the field. Mating and oviposition occurred after a short exposure to high temperatures at the end of the dormant period. The use of low temperatures immediately after emergence renders it possible to maintain dormancy for as long as 6 months and also to retard hatching of the eggs.

Outdoor Cage and Methods for Rearing Larvae.—For rearing larvae out of doors a tile cage, such as that described and used by Bryson (*1*) and as shown in Figure 119, was found most satisfactory. Bryson's procedure was to bury two unglazed drain tiles, 6 inches in diameter and 12 inches long, one above the other, tamping the earth solidly around to hold them in position. In order to avoid danger of the tiles separating and allowing the larvae to escape, it was found advisable to cement the two tiles together. A series of these cemented tiles was then placed upright 6 inches apart in a trench 22 inches deep, allowing 2 inches of the top to remain above the soil surface so that screen cages could be attached and so that debris would not wash in after rains or irrigations. After the tiles had been lined up properly the earth was replaced in the trench and firmly packed down. Plaster of paris, mixed with water to the consistency of cream, was then poured into the bottom of the tiles to a depth of one-half inch. This not only insured a larva-tight cage but also allowed for proper drainage and for seasonal changes in soil moisture similar to normal changes in the soil. These cemented cages were

FIG. 119.—In foreground, outdoor tile cages in position for rearing wireworm larvae; in background, tile with screen cage attached.

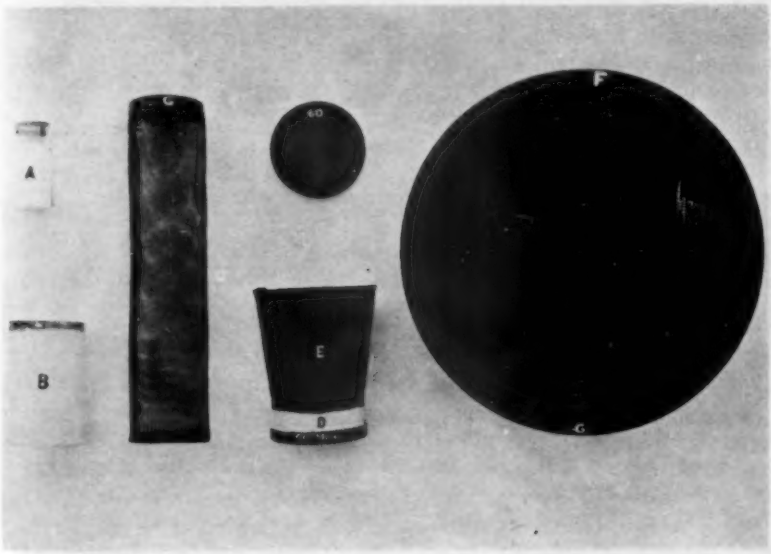

FIG. 120.—Equipment for rearing wireworms: *A*, Rearing chamber for obtaining exuviae; *B*, *C*, outdoor oviposition cage; *D*, *E*, receptacle for washing larvae; *F*, pan sifter with lower pan *G*.

broken apart for examination simply by placing one end on a block and then lightly tapping the cemented portion with a wooden mallet. Precaution was taken to make certain that the soil in the cylinder was sifted properly through a fine-mesh screen to eliminate debris and possible infestation by newly hatched or small elaterid larvae. As a further precaution, after the tiles had been filled, three-fourths of an ounce of carbon disulphide was injected 2 inches below the soil surface in each of the tiles to exterminate mites and eggs of parasitic Diptera.

After all traces of the carbon disulphide had disappeared and after a surplus of wheat and corn had been distributed throughout the cage, 25 newly hatched larvae were buried in each cage near the 12-inch depth. The larvae were fed fresh grain each month until they ceased activity late in the fall, after which they were fed small quantities at 6-weeks' intervals during the winter months. A removable cylindrical cage 6 inches high, of wire screen containing 18 meshes to the inch, (as shown attached to the tile in Figure 120), was constructed and fitted over the outside of the tile to prevent escape of the adults during emergence and to eliminate possible oviposition by other insects. The moisture content of the soil was maintained as near the optimum as possible by irrigation at various intervals throughout the year. Temperature records on the soil surface and at 2, 4, 8, and 12 inches deep were obtained by using recording thermometers of the 2-pen type, enclosed in a standard Weather Bureau instrument shelter.

A few difficulties were encountered in using the tile cages. Since larvae from one brood may mature in 1, 2, or even 3 years, it is necessary to sift the soil each year to obtain the adults before normal emergence. Females mate immediately after emergence and then frequently burrow back into the soil to oviposit. This characteristic habit makes it possible for a second brood to develop in the same cage, unless precautions are taken to avoid this occurrence.

Some larvae may be injured when the soil is being dug out for examination or when food is added. Also precautions must be taken to prevent infestations of ants or other insects that might destroy some of the larvae.

Difficulty was experienced in regulating the food supply. Insufficient food resulted in starvation and eventually encouraged cannibalism; on the other hand, an abundance of sprouting grain decreased the moisture supply in the soil sufficiently to desiccate the small larvae. It was also necessary, when placing food in the soil cages, to keep the grain separated as much as possible in order to prevent crowding of the larvae

Preparation of Soil for Oviposition.—Soil used for oviposition was first dried and then sifted through a 70-mesh screen. For sifting large quantities of this fine soil a motor-driven soil sifter was found desirable. After having been sifted, the soil was exposed to a temperature of 140°F. for 2 days to ensure destruction of fungi and mites, which attack elaterid larvae and eggs. Enough distilled or tap water was then added to bring the soil moisture up to 12 to 16 per cent by weight, as this had been found to be the optimum for both egg and larval development and for prolonging the life of adults during egg deposition. Soils

prepared in this manner and stored in sterile air-tight cans in the basement were kept at the required moisture content for several weeks.

CONSTRUCTION OF OUTDOOR OVIPOSITION CAGE.—In obtaining oviposition records mated pairs were confined without food in the basement in 1-ounce salve cans and in outdoor cages. The outdoor cage used for this purpose (Fig. 120, *B*, *C*) was constructed as follows: The lower portion (*B*) consisted of a galvanized sheet-metal cylinder 1½ inches in diameter and 4 inches in length. To the top end was soldered the rim and sides of a 2-ounce salve can. Plaster of paris was poured into this container to within 1½ inches of the top and allowed to harden. The upper portion (*C*) of the cage was constructed of 18-mesh wire screen, soldered in the form of a cylinder 2 inches in diameter and 12 inches high. To the lower end of this was soldered the rim of the lid of a 2-ounce salve can, after the cover or top part had been removed. This fits down over the rim already soldered to *B*. The top of the cage was enclosed by soldering a piece of tin to the screen. Container *B* was filled with 70-mesh soil and then placed in moist earth so that the soil, the adults, and the eggs deposited would not be desiccated.

METHODS OF OBTAINING AND TRANSFERRING EGGS.—In order to obtain data on the length of the pre-oviposition period, the soil in the salve cans, in which mated pairs had previously been placed, was washed daily. After egg deposition began, washings were made either on alternate days or at weekly intervals, depending on the time available and the type of records desired.

For the recovery of eggs and newly hatched larvae a washing device (Fig. 120, *D*, *E*) was constructed.[4] The bottom of the lower part of a 2-ounce salve can was cut out, leaving only the rim, *D*. The funnel *E*, 3 inches high and having a top diameter of 3 inches, was made to fit tightly into this rim, where it was soldered. The flat surface of the cover of the salve can was cut out and a piece of 60-mesh screen was soldered in. For smaller species, such as *Aeoleus livens* Lec., and *Anchastus cinereipennis* Esch., whose eggs are exceedingly small, 70 and 80 mesh screens were found necessary. When this cover was placed on the rim at the bottom of the funnel a receptacle was formed, into which soil containing eggs or newly hatched larvae could be emptied and the soil washed through the screen.

After all traces of the soil had been removed, the cover (*D*) was detached from the funnel and examined under a binocular microscope. Any eggs present were easily seen and counted. They were then transferred by means of a camel's-hair brush to 1-ounce salve cans half filled with moist soil, 10 to 15 eggs being usually placed in each can. The eggs were separated somewhat in order to check cannibalism or prevent its taking place immediately after the larvae hatched. The salve cans were then filled to the top with moist soil to prevent desiccation of the eggs or possible attacks by fungi during the incubation period. It was observed repeatedly that when eggs were not covered with soil, the moisture collecting on the under-side of the lid induced the growth of fungi which spread from egg to egg, sometimes causing a mortality of 100

[4]This idea was suggested by F. H. Shirck, of the Parma, Idaho, laboratory.

per cent. The watch-glass method of egg incubation was attempted in conjunction with the salve-can method, but always resulted in a heavy egg mortality, due especially to fungi or to desiccation because the moisture supply could not be regulated properly. In addition to the incubation of eggs at basement temperature, small 80-mesh screen cages containing eggs in 70-mesh soil were buried out-of-doors 2 inches below the soil surface to determine the normal incubation period.

TRANSFERRING AND FEEDING NEWLY HATCHED LARVAE.—The time of hatching was determined by washing the soil, as previously described, and examining the eggs at frequent intervals. By means of a camel's-hair brush the newly hatched larvae were removed individually from the 60-mesh screen receptacle cover to 1-ounce salve cans filled with fine (60-mesh) soil and containing 3 or 4 sprouted kernels of wheat. To simplify the keeping of records, the dates of egg deposition and hatching were written on the paper lid of each can.

At monthly intervals the soil in each of the salve cans was changed, coarse (14–mesh) soil being used eventually when the larvae and exuviae became larger and easier to locate. A surplus of water-soaked wheat, usually consisting of 10 to 20 kernels, depending on the season, was added each time the soil was changed. Soaking the wheat, for a day or two prior to feeding, not only rendered it more easily penetrable by the larvae but also prevented loss of soil moisture in the can while the kernels were germinating.

OBTAINING CAST SKINS.—Considerable difficulty was experienced in locating the cast skins of the first, second and third instars. After numerous failures in attempting to locate exuviae in the soil, a device was constructed (Fig. 120, *A*), which consisted of a section of glass tubing 1 inch in diameter and 3 inches in length, filled to three-fourths inch from the top with plaster of paris. A number of these tubes, coated on the outside with a thin layer of vaseline, were set in a shallow tray in which a half-inch layer of plaster of paris had been poured and allowed to harden. Additional plaster of paris was then poured into a depth equal to that of the height of the layer of plaster in the tubes. Before this plaster hardened completely the tubes were removed and the vaseline cleaned from the bottom so that the passage of moisture would not be hindered. A newly hatched larva was confined in each tube with a small quantity of the starchy material from a kernel of corn. The tube was then tightly stoppered. The food supply was replenished on alternate days and the block was moistened at intervals to provide as nearly as possible an optimum humidity within the rearing chamber. Larvae which were confined in this manner and kept in a dark location, fed and molted normally.

Pan sifters equipped with screen bottoms containing 16-, 20-, 30-, 40-, 50-, and 60-mesh screen were found useful in finding later larval molts and in locating larvae quickly when replenishing their food supply. The pan sifter (Fig. 120, *F*, ′) was constructed by cutting out most of the bottom of a round tin pan having a bottom diameter of about 6 inches. The desired screen was then soldered to the bottom and a lower pan provided to receive the sifted soil as it passed through the wire mesh.

For sifting large quantities of fine-mesh soil for oviposition cages, and for preparing soil for tile cages, a motor-driven soil sifter was used.

Feeding the Older Larvae.—The growth and activities of wireworms vary with the following conditions in the soil: Type, physical condition, temperature, moisture, and food supply. These conditions in turn vary with locality, the seasons and the methods of handling infested fields. In order to duplicate as nearly as possible larval activity in the field, the food supply of reared specimens was regulated accordingly. For instance, a surplus of wheat was provided in some of the salve cans from the time of hatching until activity ceased out of doors late in the fall, and the same schedule was resumed when the larvae became active in the spring. Other larvae were given only a minimum quantity of food—a few kernels of wheat during the semidormant period—to determine the effects of adverse conditions, such as commonly prevail in fields characterized by sparse vegetation; while in some cans included in the same experiment, the soil was changed but no food was given. Larvae exposed to constant temperatures of 80°F., or above, were fed biweekly, whereas those confined at basement temperature were fed at monthly intervals.

Method of Handling Prepupae and Pupae.—When the larvae reached the prepupal stage, as indicated by a swelling of the middle segments, shortening of the body, and inactivity, they were placed in small depressions made by pressing the thumb in a salve can full of moist soil. The cans were closed and the date was written on the lid. Examinations were made daily thereafter until pupation occurred. Pupae were confined in the same manner.

Handling of Adults.—Adults to be used for mating purposes either were confined in salve cans in moist soil during the winter months or, in instances of pupation in tile cages, they were allowed to remain in their pupal cells until about a month prior to normal emergence. The danger of mating occurring, should both sexes emerge simultaneously, was eliminated by removing the adults from the soil before emergence. Usually mating occurs immediately or within a few minutes after the female emerges, depending upon the temperature and the time of day. Adults that had been removed to salve cans, or confined in such cans since transformation, were provided with an artificial pupal cell constructed simply by pressing the point of a pencil into the firmly packed, moist soil with which the cans were filled. Covering the opening of the cell with additional soil not only retarded the drying out of the cell wall but prevented escape of the adult to the surface, where it would be more susceptible to attacks by fungi forming underneath the lid of the cage. By following this method, large numbers of adults were carried through the winter with only light mortality.

In order to expedite the recovery of mated pairs, a number of males and females taken from salve cans or tile cages were confined in a tall glass battery jar indoors. When the temperature remained below 70°F. a 40-watt light globe placed inside the battery jar for a few minutes had a tendency to stimulate activity and subsequent mating.

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HANDLING MOSQUITOES ON EQUINE ENCEPHALOMYELITIS INVESTIGATION[1]

By G. F. KNOWLTON and J. A. ROWE

The serious outbreak of equine encephalomyelitis which occurred in Utah during 1933 commanded the immediate attention of animal pathologists and entomologists. The epidemiology of the disease strongly suggested an insect vector. Major Kelser[2] had just reported definite transmission of this disease from guinea pig to guinea pig, and back to the horse, by means of the mosquito, *Aedes aegypti*. Merrill, Lacaillade, and Broeck[3] have subsequently reported transmission by the mosquitoes *Aedes sollicitans*, *A. cantator*, and *A. aegypti*. These species do not occur in Utah, but related forms are present in abundance. A considerable part of the time spent in insect-transmission studies has been devoted to testing out various methods of handling insects for field and laboratory study. Transmission studies were primarily confined to the family Culicidae. The principal species used in the transmission tests were *Aedes dorsalis* (Mg.), *A. nigromaculis* (Ldw.), and *A. campestris* D. and K. Smaller numbers of *A. fitchii* (F. and Y.), *A. vexans* (Mg.), *A. stimulans* (Wlk.), *A. increpitus* Dyar, *A. cinereus* Mg., *A. niphadopsis* D. and K., *Anopheles maculipennis* Mg., *Theobaldia inornata* (Will.), *T. incidens* (Thos.), *Culex tarsalis* Coq. and *C. salinarius* Coq. were also used. The material was collected in northern Utah, largely in Boxelder and Cache Counties. The writers are indebted to Dr. F. C. Bishopp of the U. S. Bureau of Entomology and Plant Quarantine; to Dr. D. E. Madsen,

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station. Authorized for publication by Director.

[2]Kelser, R. A. 1933. Mosquitoes as vectors of the virus of equine encephalomyelitis. *In* Jour. Amer. Vet. Med. Assoc., Vol. 82 (n. s. 35), No. 5, pp. 767–771.

[3]Merrill, M. H., Lacaillade, C. W. Jr., and Broeck, C. T. 1934. Mosquito transmission of equine encephalomyelitis. *In* Science, Vol. 80, No. 2072, pp. 251–252.

Animal Pathologist in charge of the disease transmission phases of this investigation, for many helpful suggestions; and to Dr. A. Stone of the U. S. Bureau of Entomology and Plant Quarantine, for identifying material from the various lots of mosquitoes collected as adults, or reared, during the course of the experiments.

COLLECTING NETS AND FIELD CAGES.—A 13- by 15-inch landing net,[4] equipped with a 60-mesh gauze, or a 25-mesh scrim bag, was used to collect adult mosquitoes for laboratory studies. Round-bottomed bags caused less injury to the mosquitoes than the sharp V-shaped type. Best captures occurred on calm, warm days from one hour before sunset until dark and upon cloudy late-afternoons. A slow, breast-high sweep eliminated most insects of other kinds, so abundant in sweepings made closer to the ground. Walking backward while sweeping usually yielded larger catches of attacking females.

Breeding grounds which yielded the largest catches were located from 10 to 90 miles from the Logan laboratory. Large, moist field cages (Fig. 121, 3, left) were used to transport the mosquitoes to the laboratory. The rectangular cages measured 18 by 23 inches on the bottom and 18 inches high, covered with 36- to 50-mesh white gauze. The upper-side of the wooden bottom was covered with a 2- to 3-inch thick cellucotton pad covered with 30-mesh gauze, except for a strip about 2 to 3 inches wide around the outer edge. A large celluloid window, bordered below by a flap of gauze to permit entrance of mosquitoes and guinea pigs, made up the front end of the cage. This type of cage proved highly satisfactory for field and laboratory storage. The bottom pad held about 3 gallons of water, which, together with the wet pad over the top, kept the cage quite humid. A cage of this size satisfactorily accommodates two to four thousand adult mosquitoes. Five such cages usually were taken into the field on each trip made to collect adult mosquitoes.

STORAGE IN THE LABORATORY.—The large field cages kept out of direct sunlight were excellent for storing mosquitoes in the laboratory. The mosquitoes received water twice daily through a 1-inch thick cellucotton pad which covered the top of each cage (Fig. 121, 3, left), and as often as necessary to keep the pad on the bottom wet. The mosquitoes fed readily upon a pad soaked with a 5 per cent sucrose solution, brain-blood emulsion, or on guinea pigs confined in gauze bags when such were laid upon the tops, or suspended against the sides of the cages.

INITIAL FEEDING UPON GUINEA PIG.—Four methods of feeding mosquitoes on the blood of infected guinea pigs were practised: (1) Before feeding, the wet pad was removed from the top of the cage. After a short time a guinea pig, clipped with either No. 2 electric, or No. 00 hand clippers (Fig. 121, 6), and wrapped in a piece of 30-mesh gauze, was laid side down (Fig. 121, 3), on the top of the cage. The mosquitoes fed readily upon guinea pigs confined in this manner. Through their ravenous feeding, freshly collected *A. nigromaculis* in one cage (Fig. 121, 4), killed two guinea pigs in 20 minutes. The bag method was utilized satisfactorily to feed from 100 to 1000 mosquitoes in a short time, using one or many diseased guinea pigs. (2) The rack method (Fig. 121, 2), was second-best; it

[4]No. 9 "Our Own", made by Richardson Rod and Reel Company of Chicago.

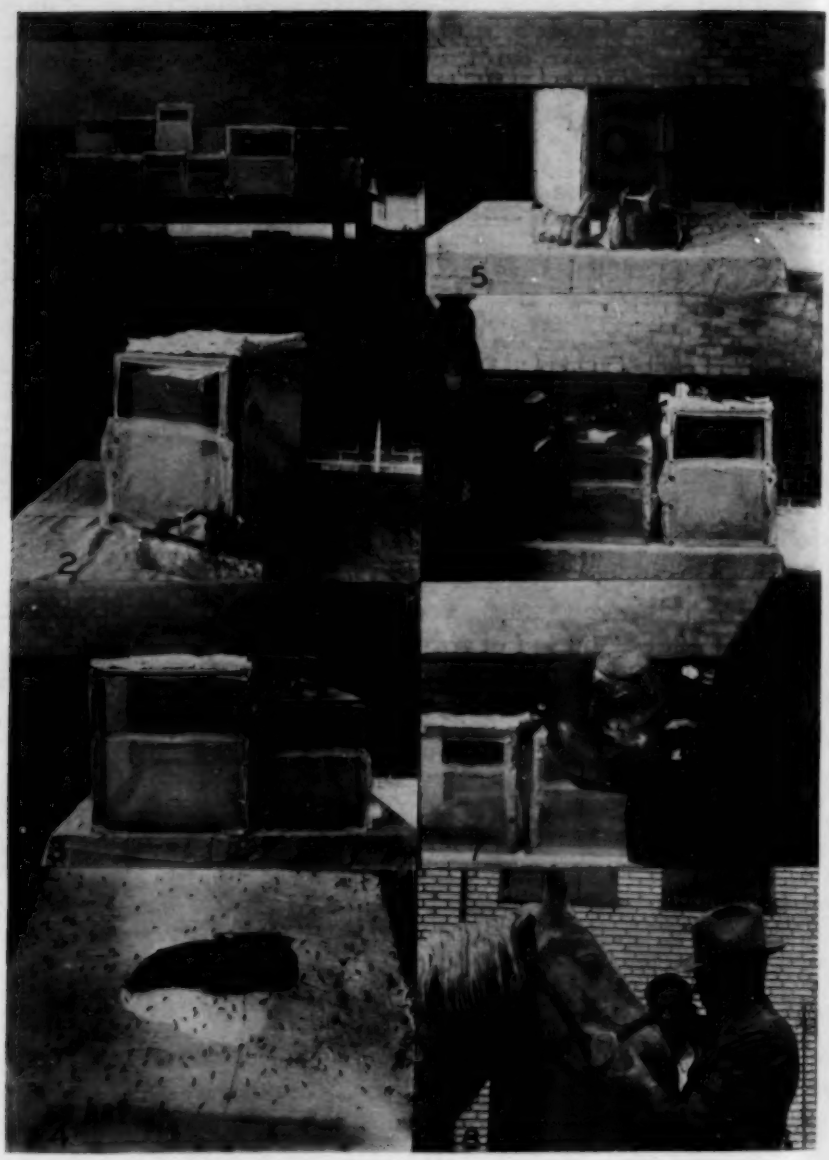

FIG. 121.—1, Refeeding and field cages; 2, diseased guinea pig on feeding rack, ready for insertion into cage; 3, field and storage cage with top pad, and refeeding cage with normal guinea pig in feeding bag; 4, mosquitoes feeding upon diseased guinea pig in gauze bag through top of cage; 5, cooling chamber and cylinder cages for field transportation of mosquitoes; 6, refeeding equipment; 7, mosquito refeeding, cylinder method; 8, feeding mosquitoes upon horse.

allowed the guinea pig considerable movement and resulted in fewer mosquitoes feeding to repletion. The guinea pig and rack are rather inconvenient to insert and remove from the cage. This method of feeding was most successful when used with fresh catches of mosquitoes. (3) After partial paralysis of the guinea pigs had been reached, it was possible to secure feeding by merely placing the guinea pig in the mosquito cage. In most cases, it was necessary to hobble the hind legs of the pig with gauze. Many unfed and a few fed mosquitoes were usually killed by the guinea pig moving about in the cage. (4) A large cage with a 24- by 40-inch bottom, and 20 inches high, was divided across the bottom half into two areas of unequal size. The smaller division was used to hold one or two diseased guinea pigs. The larger division contained a basin of water, with the balance of the bottom being covered with growing marsh grass which was wet down twice a day. Fed mosquitoes were removed to storage cages daily. The smaller compartment of this cage was also partitioned into two equal divisions, one containing healthy and the other diseased guinea pigs. The mosquitoes were free to feed upon both healthy and diseased animals. This cage proved to be unsatisfactory.

INITIAL FEEDING UPON BRAIN SUSPENSION.—Through correspondence, Dr. M. H. Merrill suggested infecting mosquitoes by feeding them upon a suspension of diseased brain. The mosquitoes fed readily upon a mixture of half glycerine-brain emulsion and half defibrinated horse blood. Mosquitoes were fed upon such a concentrate in two ways: (1) The suspension was placed into animal mesentery bags (sold as "fish skins") which were laid upon the top of a mosquito cage. Feeding resulted, but seldom to repletion. Such a membrane sack was sometimes placed between the gauze-covered adjacent ends of two cellu oid cylinders, each containing mosquitoes. (2) Mosquitoes were placed in 3- by 7-inch celluloid cylinders (Fig. 121, 5), the ends being covered with 20-mesh gauze. One end of the cylinder was placed in a petri dish containing a ⅛-inch cellucotton pad soaked with the virus suspension. Mosquitoes fed readily upon the suspension-soaked pads.

TRANSFER OF FED MOSQUITOES.—Fed mosquitoes were recognized by their pink to reddish-black, distended abdomens; they usually rested quietly upon the top and sides of the cages. Fed females were transferred to the refeeding cages by means of a straight glass tube. This sucker tube was about 36 inches long, made of 10 mm. (inside diameter) glass tubing, sometimes belled on one end to facilitate picking up the fed mosquitoes. To the end opposite the bell was attached a rubber tube with a terminal glass mouthpiece. The insects were held within the glass tube by the usual gauze obstruction. The transfer process cannot be conducted with too much care. The suction tube should never be loaded with more than 10 to 15 mosquitoes at any one time. The release or "blowing out" action should be slow, allowing the mosquitoes to find footing on the sides of the refeeding cages. With proper care the transfer can be accomplished with little injury to the mosquitoes. Injured mosquitoes rapidly lose vigor and, if still alive at refeeding time, seldom refeed.

REFEEDING CAGES AND METHODS.—The refeeding cages were similar to the field cages but smaller, the most satisfactory size used being 12 by 16 inches on the bottom and 12 inches high (Fig. 121, 6, left); the taller cages (right) were less satisfactory. Wet pads and sometimes sucrose-soaked pads were placed on the tops as in the case of the field cages. Two-inch thick cellucotton pads covered all but a narrow marginal strip around the bottom. At varying intervals after the initial infective meal, usually commencing on the third to sixth day, refeedings upon normal healthy guinea pigs were conducted, using the sack method. A rather high mortality usually occurred if the mosquitoes were not refed until the sixth day. At these feedings, usually about one-half of the mosquitoes failed to refeed upon the sacked guinea pig. Every third day the unfed individuals were transferred to small celluloid cylinder cages, 3½ inches long and 1½ inches in diameter, with the ends covered with about 20-mesh scrim (Fig. 121, 6, 7). These refeeding cages are similar to the glass cylinders used by Herms.[5] Not more than 50 females were placed in each cylinder, the scrim-covered ends of which were alternately pressed to the close clipped or shaved abdomen of the guinea pig previously used in the sack on the top of the cage.

Combining these two refeeding methods, it was often possible to obtain as high as 80 to 90 per cent refeeding every third day for three or more successive refeedings. In some experiments many of the mosquitoes would feed almost every day for a period of 6 to 14 days. Mosquitoes survived in the field and refeeding cages for from two to five weeks; small numbers lived even longer. From 100 to 3000 mosquitoes usually were fed upon diseased guinea pigs for each test, the most common number being about 400.

FEEDING UPON DISEASED HORSES.—Howitt[6] demonstrated the presence of the virus in the cardiac and peripheral blood during the early course of the disease; and also observed that it remained present during the febrile period. Mosquitoes were fed upon nearly 100 diseased horses in the field. The mosquitoes were transported from the laboratory, fed upon a diseased horse, and returned to the laboratory. Best feedings were obtained by using celluloid cylinders 7 inches long and 3¼ inches in diameter (Fig. 121, 8), the ends covered with 25-mesh bobbinet. Approximately 100 mosquitoes were used in each cylinder and three to five cylinders used upon each horse. A "cooler" (Fig. 121, 5), was constructed to hold approximately 25 cylinders. This "cooler" was made from a rectangular box 14 by 19 by 21 inches high. Two sides were of wood, covered on the inside by a 2-inch thick cellucotton pad. The other two sides were covered with double gauze between which were placed 1 inch thick cellucotton pads. The bottom was elevated 3 inches and was made of doubled 50-mesh gauze. When soaked with water, this "cooler" produced a fairly high humidity and allowed proper circulation of air

[5]Herms, W. B., Wheeler, C. M., and Herms, H. P. 1934. Attempts to transmit equine encephalomyelitis by blood-sucking insects, especially mosquitoes. *In* Jour. Econ. Ent. 28: pp. 987–998.

[6]Howitt, B. F. 1932. Equine encephalomyelitis. *In* Jour. Infect. Diseases, Vol. 51, pp. 493–510.

through the gauze bottom and sides. During hot weather mosquitoes survived much longer when carried in such a container.

The ends of mosquito-laden cylinders were held against the horse at the nose (Fig. 121, 8), jaw, neck, perineal region, or rump. If the hair of the horse was too long to permit ready feeding, a small area was clipped, using 8-inch serrate-edged scissors. During excessively hot weather, the best feedings were obtained in shaded places during late afternoon and early forenoon. Under favorable conditions, 60 to 90 per cent of the mosquitoes in the cylinders would usually feed. Percentages were lowest during the middle of extremely hot days. The mosquitoes were returned to the laboratory, as soon as possible, the fed females being separated out and placed in refeeding cages and the unfed individuals destroyed.

AN INVESTIGATION OF SOLVENTS FOR THE REMOVAL OF INSECTICIDAL FLUORINE RESIDUES FROM FRUITS

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In 1933 an investigation by Smith et al. (4) demonstrated the need for better solvents for removing insecticidal fluorine residues from fruits. This paper reports the results of a study of the solubility of cryolite to find, if possible, a solvent that would facilitate the removal of such fluorine residues.

Solvents for the removal of fluorine residue will be expected to remove arsenic and lead residues also, because all three are left from mixed spray schedules. Since acid has been found very effective in removing lead and arsenic residues, most of the solvents tested were mixtures of salts with hydrochloric acid or sulfuric acid. Some of the commonly used alkaline washes were also tested, as well as solutions of some common salts in water.

The solubility of cryolite in a number of solvents was determined by the following procedure: Five grams of cryolite were added to the solvent (200 cc.), which had been cooled to 20.0°C. (68.0°F.) ± .1°. The mixture was shaken vigorously for 3 minutes and then filtered rapidly through paper. Aliquots of the filtrate were then distilled according to the procedure of Willard and Winter (5) using sulfuric acid. Aliquots of the distillate were then titrated with standard thorium nitrate solution, sodium alizarin sulfonate being used as indicator, according to the method of Armstrong (1). The results, in grams of fluorine per 100 cc. of filtrate, together with the solvents used and their concentrations, are given in Table 1.

It is noted that hydrochloric acid is a fairly good solvent for cryolite but that the addition of certain salts—for example, sodium chloride—represses the solubility of the cryolite. This is perhaps due to the "common-ion effect", but the same effect is also noted in some cases where there is no common ion. The addition of small amounts of other sodium salts also represses the solubility of cryolite in water, as has been pointed

out in a previous publication (2). The same phenomenon has also been noted by Frere (3).

TABLE 1. EFFECT OF VARIOUS MATERIALS ON THE SOLUBILITY OF CRYOLITE AT 20° C. (68° F.) IN WATER AND IN DILUTE HYDROCHLORIC AND SULFURIC ACIDS.

Materials	Concentration, grams/100cc. H_2O	Fluorine,* grams per 100 cc.	
		HCl, 1.5%	H_2SO_4 ≏ 1.5% HCl
None (cryolite only)	0.0220	0.2404	0.1857
Borax, $Na_2B_4O_7$	1.0	.0114	
	0.25	.0070	
	0.125	.0062	
Boric acid, H_3BO_3	1.0	.5576	.3791
	2.0	.5812	.3793
	3.0	.5272	.3809
Silicic acid, $Si(OH)_4$	1.0	.3281	.2364
Stannous chloride, $SnCl_2.2H_2O$	1.0	.2917	.2736
Arsenic trioxide, As_2O_3	1.0	.2680	.2029
Chromic oxide, Cr_2O_3	1.0	——	.2277
Boric acid, H_3BO_3 + sodium phosphate, Na_2PO_4	2.0 + 2.0	.2711	.1394
Trisodium phosphate, Na_3PO_4 (com.)	2.0	.0628	.0768	.0355
	10.0	.0731	
Monosodium phosphate, $NaH_2PO4:4H_2O$	0.25	.0049	
Sodium chloride, NaCl	2.0	.0077	.0952	.0516
	5.0	.0045	
Potassium chloride, KCl	2.0	.0922	.0966
Aluminum sulfate, $Al_2(SO_4)_3:18H_2O$ + boric acid, H_3BO_3	2.0 + 2.0	.4881	.3796
Aluminum sulfate, $Al_2(SO_4)_3.18H_2O$	1.0	.2091	
	2.0	.3207	.4013	.3812
	5.0	.4139	
Aluminum chloride, $AlCl_3$	5.0	.7530	
Sodium silicate, Na_2SiO_3 (69° B.)	2.0	.0553	
	10.0	.1096	
Sodium bicarbonate, $NaHCO_3$	0.125	.0039	
Sodium carbonate, Na_2CO_3, anhyd	10.0	.0159	
Ferric chloride, $FeCl_3.6H_2O$	2.0	.3694	.4753
	5.0	.5592	
Ferric sulfate, $Fe_2(SO_4)_3$	2.0	.3033	.3483
	5.0	.4071	.5201
Ferrous sulfate, $FeSO_4.7H_2O$	2.0	.0481	.2250
	5.0	.0453	.1945
Cupric sulfate, $CuSO_4.5H_2O$	5.0	.0288	.1964
Magnesium sulfate, $MgSO4.7H_2O$	2.0	.0451	.1916
	5.0	.0372	.1940
Zinc sulfate, $ZnSO_4.7H_2O$	2.0	.0483	.2367
	5.0	.0445	.1955
Alum, $K_2SO_4:Al_2(SO_4)_3.24H_2O$	2.0	.3187	.3125
	5.0	.4387	.4769
Potassium sulfate, K_2SO_4 ≏ (2.0 g. alum)	0.36	.0051	.2205
≏ (5.0 g. alum)	0.91	.0025	.2604
Sodium hydroxide, NaOH	1.0	.5124	

*Results are given in terms of fluorine because that is the insecticidal element. Grams of fluorine can be converted to grams of cryolite by multiplying by the factor 1.84.

On the other hand, certain compounds increase the solvent action of water or dilute hydrochloric acid for cryolite. Those that were the most efficient at the concentrations studied were boric acid, aluminum salts such as the sulfate and chloride, and ferric salts such as the sulfate and chloride. The reasons why these compounds are effective have not been definitely established, but are probably linked up with the formation of complex salts, as it is known that complex salts of fluorine with boron, aluminum, and iron do exist.

Of the alkaline compounds tested, sodium hydroxide was much the best. Solutions of sodium silicate, sodium carbonate and bicarbonate, and tri-sodium phosphate do not effect decomposition of the cryolite.

Those compounds that increase the solubility of cryolite should be of some value in removing spray residues containing fluorine. The relative efficiency of these compounds can only be determined by actual

trial under field conditions, because residue removal is complicated by many factors in addition to the insolubility of the insecticidal spray materials. Experiments along this line are now under way.

SUMMARY.—Some compounds, notably sodium salts, when added to water and to aqueous solutions of mineral acids, decrease the solubility of cryolite, whereas some other compounds, such as boric acid and aluminum and ferric salts, increase its solubility.

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FURTHER STUDIES ON THE EFFECT OF CONTROLLING THE POTATO LEAFHOPPER (*EMPOASCA FABAE* HARRIS) IN ALFALFA BY DESIGNED CUTTING[1]

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Data taken from the first cutting of alfalfa plots in 1934 show that where the plots were cut on different cutting schedules in 1933, the control of the leafhopper after cutting, either by spraying or by the cutting itself, exerted a marked influence on the ability of the plants to yield satisfactorily. During the growing season of 1933, two pairs of duplicate plots of Grimm alfalfa were cut on different cutting schedules to determine the effect of cutting on the subsequent occurrence of the potato leafhopper (*Empoasca fabae* Harris) and leafhopper yellows, a disease which the insect causes in alfalfa. One of each pair of plots was 12.5 ft. x 35 ft. while the other was 17.5 ft. x 35 ft. One pair of plots had been cut as on a three-cutting schedule on June 13 and again on August 4. The third cutting was not made because of the weakened condition of the unsprayed parts of the plots and the desirability of further experimentation with the plots. The second pair was cut on June 27 and August 19. One-half of each pair of plots was sprayed periodically to control the leafhoppers while the other half was not treated. In every instance it was assumed that, since conditions were identical in the treated and untreated plots except for the spray treatment for insect control, the difference in yield was due solely to the activity of the insect in the unsprayed areas.

[1]Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

In this experiment it was found[2] that compared with the earlier cutting, the deferred cutting was a satisfactory and efficient control of the insect; also that, in controlling the insect, leafhopper yellows was eliminated and the yield of alfalfa much increased over the unsprayed plots used in the earlier cutting. Many more weeds were found in later growths on the early cut, unsprayed areas thereby showing that plants weakened by insect feeding were not able to compete with the weeds.

As the early season of 1934 progressed it became increasingly obvious that the unsprayed halves of the plots cut early in 1933 had suffered very severely as compared either with the sprayed portions of the same plots or with the sprayed or unsprayed portions of the plots in which deferred cutting was used to control the insect. It was also quite obvious that where the insects were controlled, the alfalfa plants were more vigorous and fewer weeds had grown. The plots which had been freely fed upon by the insects and had consequently suffered severely from the disease had been so reduced in vitality that the plants were no longer able to compete with the weeds which had appeared in great numbers.

The plots cut on June 13 and August 4 in 1933 were cut on June 11, while the other pair of plots was cut on June 12, 1934. The total amount of green material cut from the plots was weighed. A sample from each plot was also selected at random and weighed, all material except alfalfa removed, and the remainder weighed again. In this way the total yield of alfalfa and the amount of weeds on each part of each plot was determined. The results thus obtained from the 1934 growth clearly demonstrated the effect of controlling the leafhopper in 1933.

It was found that the sprayed plots cut early in 1933 yielded at the rate of 5,197 pounds of green alfalfa per acre for the first cutting in 1934. The unsprayed parts of the same plots yielded at the rate of 3,237 pounds per acre. At this rate, controlling the leafhopper increased the yield on the treated area 1,960 pounds per acre, an increase of 60.5%. The unsprayed area also contained nearly twice as many weeds as the sprayed.

The sprayed areas in the deferred cutting plots produced only 644 pounds more alfalfa per acre in 1934 than the unsprayed area and contained about 2% less weeds. These figures clearly show that deferred cutting had been so efficient in controlling the leafhopper and reducing leafhopper damage to the plant in 1933 that the difference in yield of the first cutting in 1934 was not great enough to have justified spraying costs even if spraying were practical on large areas. The sprayed areas of the early cut plots produced alfalfa at the rate of 5,197 pounds per acre while the unsprayed areas of the deferred cutting plots produced at the rate of 5,495 pounds per acre. In this case deferred cutting was at least as effective in controlling the insect and maintaining the vitality of the plant as an intensive spray program had been in the early cut plots.

There are many factors which influence the ability of alfalfa to survive over a period of years in Wisconsin. In this instance, however, since conditions were identical in all of the plots except for the cutting dates

[2]Searls, Ed. M. The effect of alfalfa cutting schedules upon the occurrence of the potato leafhopper (*Empoasca fabae* Harris) and alfalfa yellows in Wisconsin. Jour. Econ. Ent. Vol. 27, No. 1, pp. 80–88. 1934.

and the leafhopper control measures practiced, leafhopper injury was the apparent cause of the failure of the unsprayed areas of the early cut plots of 1933 to produce a satisfactory yield in 1934.

The sprayed areas of the early cut plots produced within about 300 pounds per acre as much alfalfa as the unsprayed areas of the deferred cut plots. In the absence of the leafhopper the alfalfa produced a reasonably satisfactory yield for the first cutting the next year.

This experiment would indicate that under field conditions when there is a heavy infestation of the insects, leafhopper injury may be so severe as seriously to interfere with the ability of the plants to maintain their productivity.

Scientific Notes

Corn Earworm Fails to Overwinter at Ames, Iowa. Several screen cages were placed over cultivated ground and one over grass sod in November 1934. About 500 ears of corn containing nearly mature earworms were placed in each cage and the worms were then allowed to pupate in the normal manner in the ground. Observations made during the spring of 1935 failed to show any emerging adults in the screen cages. A number of pupae were dug up in corn fields during March and all were dead. The winter of 1934–35 was rather cold. The ground was covered with 4 or 5 inches of snow during part of the winter, and the temperature dropped to as low as —28° F.

This would seem to lend considerable weight to the theory that the corn earworm does not overwinter as far north as Central Iowa. The cages are being kept under observation during the summer and fall to determine if there is any delayed emergence. At the present time, July 6, 1935, no adults have emerged.

Ross E. HUTCHINS, *Department of Zoology and Entomology, Iowa State College, Ames, Iowa*

Evidence of the European Elm Bark-beetle Found in Western Massachusetts. During the past season a survey was made of the elm bark-beetles of Massachusetts. This work was done in conjunction with the scouting which was carried on for the Dutch Elm Disease in this state. Three specimens of elm wood and bark which showed the presence of *Scolytus multistriatus* Marsh., the smaller European elm bark-beetle, were sent in to the laboratory from Western Massachusetts. One was from the town of Westfield in Hampden County and the other two were from the town of Egremont in Berkshire County. These towns are far removed from the limits of the infestation of this beetle which centers around the city of Boston. However, the New York infestation of this beetle extends to points in Connecticut and in New York State which are quite close to these two locations in Western Massachusetts, so it is probable that the beetle spread to Westfield and Egremont from the New York area rather than from the infested region surrounding Boston.

W. B. BECKER, *Dutch Elm Disease Laboratory, Dept. of Entomology, Mass. Experiment Station, Amherst, Mass.*

Calomycterus setarius **Roelffs in Maryland.** On July 3, 1935, the Assistant County Agent of Baltimore County, Mr. William H. Carroll, Towson, Maryland, reported that a small weevil was invading a house in a suburban development in Towson. Upon investigation it was learned that this weevil, which was determined by Mr. L. L. Buchanan of the United States National Museum as *Calomycterus setarius* Roelffs (Japansee weevil), had been present the previous season but had not been reported. Over a period of approximately three weeks the beetles were entering a house and collecting in the area ways by the thousands. No difficulty was experienced in scraping up weevils by the handful from area ways and on the floor of a basement recreation room. It was later learned that a second house, approximately 100 yards away, was likewise invaded. These two houses were the only dwellings in a new

development lying about one-quarter mile away from Loch Raven. The houses are surrounded by fields. Grass, clover and the usual weeds constitute the cover of these fields.

Around the house weevils had destroyed practically all of the foliage on the roses and had fed on the following plants: red clover, hollyhocks, Hemerocallis, red top, ivy, Pyrocanthus, marigold, iris and milkweed. The most serious injury was to the roses, marigold and ivy, the latter being completely stripped of its foliage at the second house invaded. The owner reported that large numbers migrated across the concrete road in front of the house and disappeared, but most of them seemed to congregate around the house or around the stone wall next to the garage.

No pairing was observed either among the thousands crawling about the house or in collected specimens kept in cages, possibly indicating a parthenogenetic habit.

ERNEST N. CORY, *State Entomologist, College Park, Maryland*

Lights for Light Traps. There is considerable interest in light traps for insect control and several papers on various phases of this subject have appeared in the Journal. A communication just at hand from Mr. S. G. Hibben, Director of Applied Lighting, Westinghouse Lamp Company, calls attention to data necessary for the accurate comparison of different experiments. He states that experimentors operating with different light sources seldom have a sufficiently complete knowledge of the characteristics of the lamp. Comparisons between different colored lamps, for example, might result in the erroneous conclusion that the effects were the result of color quality whereas probably the greater differences were due to varying intensities. In such work it is important to note the total output of luminous flux and perhaps also, the visible candle power. In the case of the yellow lamp, this may be about 50 per cent of the uncolored white lens. A red lamp of the same wattage might have an output of 20 per cent and the blue lamp might be as low as 2 per cent of the clear lamp. This specialist in lights considers it advisable to measure the amount of energy produced in each band of the spectrum and to note carefully the differences between the different qualities of ultra-violet lights. He states that slight changes of temperature or of pressure will change the ultra-violet quality of the average lamp. The newest illuminants in the hot cathode or high intensity mercury or sodium lamps produce broken line spectra which are also quite sensitive to external conditions, and it is impossible to make accurate comparisons of the attractive or repelling power of such lights without a knowledge of the qualitative as well as the quantitative characteristics of the light source.

E. P. FELT

Mosquitoes Annoy Sheep. The presence of large numbers of mosquitoes in the canyons and mountains west of Woodruff (Rich County), Utah, was called to the writer's attention on July 3 by W. H. Hendricks, Utah State Veterinarian. Dr. Hendricks had been called to the affected area to examine sheep, which had been biting themselves upon the rump, sides of the abdomen and in the vicinity of the flanks, until raw bloody areas were produced. The cause was not "scabies", as had been at first suspected. On July 5, a trip was made to the Randolph-Woodruff area to look into the mosquito conditions upon the range. Both towns are located in a large flat valley which is covered principally by moist pastureland—an ideal mosquito breeding area. A trip was made into the canyons and mountains to the west and southwest of Woodruff, where range plants were found to be in good condition. Wherever mountain meadows were examined, mosquitoes were present in enormous numbers. Mosquitoes were almost equally abundant in the vegetation along mountain streams, in patches of aspen, and even among sage and rabbitbrush. Mosquitoes were extremely abundant and annoying even upon the tops of the mountains, at an elevation of approximately 8000 feet. Sheep with incrusted raw areas were caught and held. Mosquitoes of three species quickly demonstrated that they had little difficulty in finding places to feed upon the sheep, as they quickly crawled down among the wool on the head, fed where the wool was rubbed off or parted upon the sides, upon the udders of the ewes, and wherever the recently clipped fleeces would permit entry. The species of mosquitoes present were, *Aedes dorsalis* Coq., *A. idahoensis* Theob., and *A. inornatus* Will (Det. Dr. A. Stone). Sheep owners and herders reported that the sheep frequently refused to enter the aspen groves, where the mosquitoes were excessively an-

noying; when the sheep did enter such places and were heavily attacked, they would leave the sheltered places and seek the open areas where they would mill around in circles, stirring up huge clouds of dust. The great abundance of mosquitoes at some distance from their breeding areas was of considerable interest. It seemed that the heavy mosquito attack induced the sheep to turn and bite the accessible parts of their bodies, thus producing the raw, scabby areas observed upon a considerable number of both sheep and lambs.

G. F. KNOWLTON and D. E. MADSEN, *Utah Agricultural Experiment Station, Logan, Utah*

Insects Infesting Cottonseed Meal.[1] Six species of insects were taken during August, 1935, from cottonseed meal stored in burlap bags in barns at the Georgia Experiment Station. There were two lots of meal, one secured about January and held in a feed barn and stable, and the second secured in July and held in a new building which housed nothing else but chemical fertilizers. The meal was ground and sacked at a local mill. Both lots were of the crop of 1934.

The insects included five species of Coleoptera, as follows: *Lasioderma serricorne* (Fab.), *Sitodrepa panicea* (L.), *Tenebroides mauritanicus* (L.), *Tribolium confusum* Duval, and *Attagenus piceus* Oliv., and one species of Lepidoptera, *Ephestia kuehniella* Zell. *Tenebroides* and *Attagenus* were found only in the larval stages, *Tribolium* only in the adult, while *Lasioderma* and *Sitodrepa* were found in larval, pupal and adult stages. *Ephestia* larvae were in the meal and moths were found on the outside of the bags. The older meal contained all the species but *Lasioderma* and *Sitodrepa* were more common than the others. Larvae of these beetles make oval cases of the meal and bits of hull for pupation, about 4 by 3 millimeters. Only *Tribolium* adults and *Ephestia* larvae were found in the newer meal.

Infestation of cottonseed meal may occur in several ways. Probably the most common is through the walls of the bag. The bags examined were of burlap, 9.4 threads to the inch, with spaces between threads about 1.75 mm. wide. Meal easily sifts through the fabric and covers the outside of the bags. It is obvious that all the insects found can pass through bagging of this type.

There is a possibility that the meal may be infested before bagging. The cottonseed cake, which is the cooked kernel and part of the hull from which the oil has been expressed, may stand months before being ground into meal. These cakes are very dense and do not appear to be suitable for insect habitation except possibly on the edges which are left in a rough state when they are trimmed for the residue of oil they contain. Grinding, which immediately precedes bagging of the meal, merely breaks up the cakes into meal, already pulverized through pressing, and pieces of hull which are as great as 5 millimeters across. Thus it appears that insects on the cakes, either in the egg or later stage, might go through the grinding mill alive.

A third mode of infestation is from the use of second-hand bags which are likely to contain insects on residues of food material.

It will be noted the insects found are all well known pests of other stored products.

THEO. L. BISSELL, *Experiment, Georgia*

The Screw Worm (*Cochliomyia americana* C. & P.) Failed to Survive the Winter of 1934–35 in Iowa.[2] An outbreak of the screw worm (*Cochliomyia americana* C. & P.) in northwestern Iowa during the late summer of 1934 aroused considerable concern among veterinarians and livestock growers in that region. A survey (Knipling and Tate, Jour. Econ. Ent. 28: 472–475, 1933) disclosed numerous cases of myiasis in various localities of four different counties.

Apparently this was the first authentic record of the occurrence of this species in Iowa and to the writer's knowledge it had not been reported previously from other latitudes as far north as this. It seems probable that this pest either migrated considerably farther north than its normal range during the exceptionally long dry hot summer of 1934 or was introduced into Iowa on infested cattle from the Southern States. Since the screw worm has become a major livestock pest in many of the Southern States, it seemed to be of considerable importance to determine if it could survive winter conditions in Iowa and thus establish itself permanently in this area.

[1]Published as No. 42, Journal Series, Georgia Agricultural Experiment Station.
[2]Journal Paper No. J-283 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 372.

Date		Conditions				Insects							
						Diptera		Hymenoptera		Lepidoptera		Hemiptera	
July	Time	Temp.	R. H.	Wind	Sky	G. & S.	No.	G. & S.	No.	G. & S.	No.	G. & S.	No.
16	4 p.m.	81	62%	Light	Clear	Eristalis arbustorum L.	1	Apis mellifica L.	2	Thymelicus mystic Scud.	1	———	–
						Sphærophria cylindrica Say	1	Halitcus planatus Lovell	3				
						Phenecia cæruleviridis Macq.	5						
						Graphomyia maculata Scop.	1						
18	9 a.m.	77	73%	Light	Cloudy	Phenecia cæruleviridis Macq.	3	Apis mellifica L.	4			Lygus pratensis L.	3
						Sphærophria cylindrica Say	4	Bombus spp.	1				
						Desmomyra confusa Curran	2	Halictus pilosus Sm.	5				
19	3 p.m.	90	53%	W. mod.	Clear	Sphærophria cylindrica Say	6	Apis mellifica L.	8				
						Melanostoma pictipes Bigot	2	Halictus provancheri D. T.	4				
						Eristalis arbustorum L.	4						
						Eristalis saxorum Wd.	1						
						Tabanus trispilus Wd.	1						
						Phenicia cæruleviridis Macq.	2						
						Mericia ampela Macq.	1						
						Rhynchioderus spp.	1						
20	10 a.m.	73	75%	NE mod.	Clear	Sphærophria cylindrica Say	6	Apis mellifica	5				
						Graphomyia maculata Scop.	1	Halictus sparsus Robt.	1				
						Mesogramma marginatum Say							
						Hylemyia spp.							
22	2 p.m.	80	70%	S mod.	Cloudy	Phenicia cæruleviridis Macq.	3	Apis mellifica	6			Lygus pratensis L.	1
						Eristalis arbustorum L.	2	Halictus lineatulus Cwfd	3				
						Syritta pipiens L.	2						
						Hylemyia spp.	2						
27	11 a.m.	70	62%	S light	Clear	Eristalis arbustorum L.	2	Apis mellifica L.	5			Lygus pratensis L.	1

In order to obtain material for study a sheep was wounded and then infested by confining a gravid female of *C. americana* in a small cage over the wound. A similar procedure was followed in infesting rabbits from which some material was also secured. From these animals large numbers of fully matured larvae and pupae were collected and placed in various situations during November (1934) for the purpose of obtaining overwintering records. An effort was made to subject the insects to various conditions, some of which it was hoped might be comparable to those which would be encountered in nature.

During the latter part of November the sheep which had been infested with maggots was caged out-of-doors so that some of the larvae, upon reaching maturity, could escape from the wound and pupate normally in the soil. Over 300 larvae and pupae were liberated in a mixture of straw and manure in an unheated section of the greenhouse. A box two feet in depth was sunk to the ground level out-of-doors and filled with compost upon which 247 larvae were released. Some 200 larvae were placed in compost at about two feet below ground level under out-of-door conditions and covered with soil.

On November 12, for examination at intervals during the winter months, 120 larvae and 90 pupae were confined in a number of small ventilated metal boxes and placed in the soil under field conditions at various depths ranging up to two feet. An examination of this material on December 3 showed that the larvae had transformed to the pupal stage and that all the pupae, in both cases, were dead. In addition 75 pupae obtained from larvae which had been collected from a natural infestation in a cow on October 3 (1934) were covered with two inches of sand under field conditions and 75 others were put in straw and then covered by two inches of sand.

Cages were placed over all these points and observations were made at frequent intervals throughout the following spring and early summer (1935). In no case did adults emerge. These observations indicate that *C. americana* can not survive the winter at Ames, Iowa. On the other hand, the possibility of such an occurrence during mild winters is realized.

H. D. TATE, *Iowa Agric. Exp. Station, Ames, Iowa*

Notes on Insects Pollinating Onions. In connection with studies made of thrips resistant strains of onions of the Massachusetts Experiment Station, some observations were made during the summer of 1935 on the different species of insects found pollinating onions. These insects were collected to secure specimens at different hours during the day. Weather conditions were also recorded since the flight of insects varies with the weather conditions.

The following table lists the insects found pollinating onions. The Diptera were determined by Dr. C. H. Curran and the solitary bees by Miss Sandhouse. The remainder of the specimens were identified from material in the collection at the Massachusetts State College.

From the table on page 836 the following facts are evident.

1. *Apis mellifica*, with one exception, was more numerous in each collection than any other insect, totalling 31.8 per cent of all the insects caught.

2. The total number of Diptera collected exceeded the total of any other Order. However, with the possible exception of *Eristalis arbustorum*, *E. saxorum*, *Mericia ampela* and *Graphomyia maculata*, the flies do not seem to be structurally fitted for carrying pollen.

3. Of the other Orders recorded, none would seem to be of value as pollinators because of lack of numbers or because of lack of structures suitable for distributing pollen.

4. The insects in order of importance and abundance as pollinators of onions were:

Apis mellifica	31.8 per cent of total.
Halictus sp.	14.9 per cent of total.
Eristalis arbustorum	8.4 per cent of total.

F. R. SHAW, A. I. BOURNE and C. L. LOTHROP

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The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.50 per page. There is a charge of $3.50 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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A. A. A. S. Winter meetings, December 1935, St. Louis; December 1936, Washington; December 1937, Indianapolis, Ind. Summer meetings, 1935, Minneapolis; 1936, Rochester, N. Y.; 1937, Denver, Colo.

Sanitary problems, in cities in particular, are complex and it is not surprising that such activities should be placed in the hands of sanitary engineers. Pest control or extermination in its relation to insects in dwellings and other structures definitely falls within this scope and although the problems are primarily entomological, nevertheless, they come under the general provisions of municipal sanitation and in view of this, one can hardly take exception to their being placed in that category. The licensing and supervision of vermin extermination, if there is to be such, should most certainly be administered by those thoroughly versed in both the practical and technical phases of this work. Municipal sanitarians are infrequently entomologists or men with entomological training, and yet, it is possible that such officials can be educated to the technical requirements of such work and this may result in a material improvement from the professional standpoint in regulations and administrative practises of sanitary departments in relation to the control of household pests. Certainly this is a field which has not been given much attention by most entomologists. Yet, it is one with distinct promise of service and at least moderate compensation.

The Index of American Economic Entomology covers a twenty-five year period and by recent vote of the Association, the publication of another volume covering a five year period was authorized. There was an expectation at that time that compilation of this Index could be taken care of by the Federal Bureau of Entomology and Plant Quarantine in the same manner that earlier volumes were prepared under the then Federal Bureau of Entomology. It has not been possible to arrange this, though it is generally admitted that there are no better facilities for the

compilation of such a work than at Washington, and it is also well recognized that such an Index is an indispensable aid in the numerous lines of research conducted by agents of the Bureau, not only in Washington, but in other parts of the country. In other words, the Index is a decidedly useful book and it would seem that an expenditure of possibly $6,000 for this compilation would prove a most economical method of facilitating the work of the Bureau, not to mention the great value such an Index would possess for other entomologists, not only in this country but in other parts of the world. There is an entire willingness on the part of the Bureau authorities to supervise this compilation. The problem is in arranging to have this work done. The Editor would greatly appreciate suggestions as to methods of bringing this about.

Current Notes

By a recent amendment to the Statutes of McGill University, Dr. W. H. Brittain, Professor of Entomology and Dean, Faculty of Agriculture, becomes Vice-Principal of Macdonald College with jurisdiction, under the Principal of the University, of the Faculty of Agriculture, School of Household Science and School for Teachers.

Mr. C. P. Clausen of the U. S. Bureau of Entomology, Washington, D. C., and H. L. Parker, who is stationed at the Bureau of Entomology laboratory at Hyeres, France, represented the Bureau of Entomology at the recent meeting of the 6th International Congress of Entomology in Madrid, Spain, September 6 to 12.

Dr. Arthur Gibson and H. G. Crawford of the Entomological Branch, Ottawa, Canada, were the official representatives of the Canadian Entomological branch to attend the International Congress of Entomology at Madrid, Spain, and the Imperial Conference of Entomology in London, September 19–28.

Mr. R. E. Balch of the Canadian Entomological Branch states that counts made at Parke Reserve, Quebec, indicate a decrease in the populations of European Spruce Sawfly amounting to approximately 50 per cent as compared with the spring population of 1934. Shrews, mice and squirrels are largely responsible for the reduction.

Dr. R. D. Bird of the Canadian Entomological Branch reports that present indications point to a rather marked reduction in the grasshopper population in Canada next year with concentrations of the insect in certain definite areas. A fungus parasite, *Empusa grylli* Grt. has been very abundant in most sections of Manitoba, destroying a large percentage of the hoppers, particularly the clear-winged grasshopper.

Horticultural Inspection Notes

The red raspberry mosaic disease is the subject of a quarantine placed by the Oregon Director of Agriculture on July 19, requiring two inspections during the season before shipping raspberry and blackberry plants from one place to another within the State.

According to a California quarantine circular, the Utah State Board of Agriculture amended its Quarantine Order No. 8(a), pertaining to the tomato pinworm, to require certification as to absence of the worm, not only as to tomato plants from California, Pennsylvania, Delaware, and Missouri, but also as to tomato fruits from these States and to require that all tomato plants are free from certain noxious weeds. The amendment became effective on June 27.

Alfalfa weevil quarantines of Nebraska and South Dakota, as recently reissued, include in the restricted area the recently infested counties of Coconino in Arizona,

and Montezuma in Colorado, as well as Scotts Bluff and Sioux Counties in Nebraska. The Nebraska quarantine, which became effective on August 31, makes provision for shipping alfalfa hay during the winter, when chopped and blown into the car. The South Dakota quarantine which became effective on September 1, remains prohibitive as to the entry of the restricted articles.

California quarantine orders relating to the downy mildew of hops, which were placed in November and December 1934, restricting the movement of hops into uninfected counties of California from other States or counties in the State, were revoked effective June 19. The intrastate quarantine regulation relating to the vegetable weevil was also revoked June 27. These revocations were based on the fact that the pests concerned were rather generally distributed in the State, and that the weevil is of little economic importance to the production of vegetable crops in the State.

The first definite cases of the phony peach disease in Maryland and Kentucky came to light in the recent survey of peach growing areas in these States. In Maryland two infected trees were discovered in Washington County, and one in Worcester County. In Kentucky two each were found in Henderson and Graves Counties and one each in Webster and Union Counties. This work is part of a general cooperative Federal and State survey of territory bordering on the north of the known infected area, for the purpose of finding and eradicating any trees so diseased.

A California State inspector recently reported the interception of a quart of fresh blueberries arriving by airmail at Pasadena from Litchfield, Conn., without Japanese beetle inspection. The fruit was destroyed on order of the postmaster.

Owing to the heavy movement of plants and plant products from the Northeastern States through Cincinnati to points in important agricultural regions, the Bureau of Entomology and Plant Quarantine has stationed a transit inspector in that city on a permanent basis for the enforcement of Federal domestic quarantines. A new railway terminal was recently erected in this city.

Forty-eighth Annual Meeting of the

American Association of Economic Entomologists

St. Louis, Mo.

December 30, 1935 to January 1, 1936